The Agricultural Journal of India

Edited by

The Agricultural Adviser to the Government of India

Vol. XXI

(1926)

PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

Calcutta: Government of India
Central Publication Branch
1927

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EDITORIAL

AGRICULTURAL RESEARCH INSTITUTE, PUSA.

The Scientific Reports of the Agricultural Research Institute, Pusa, for the year 1924-25 give an interesting account of the work done therein. They show that the main aim of this Research Institute is to establish principles which can be applied to local problems by Provincial Departments of Agriculture.

In the Botanical Section of the Institute, a new and promising type of wheat, Pusa 52, has received further trial, and has been found to compare well both as regards yield and rust resistance with Pusa 4 and Pusa 12 which have now an established position, more especially in the agriculture of Northern India. Pusa 52, moreover, is a bearded variety and is not therefore liable to damage by birds and animals. With a view to evolving a type of tobacco resembling American varieties in flavour, colour and smoking qualities, while possessing the hardiness and yielding capacity of the best Indian varieties, the American Adcock and Burley have been crossed with the well known Pusa Type 28. Very good results were obtained during the year in the curing of Burley by air-curing on racks, both with the split stem method and by stringing the leaves. Hybridization is being employed for producing a large-seeded linseed with a root system adapted to the Gangetic alluvium. Work on pigeon-pea is proceeding on two lines, namely, the separation of unit species from the mixed field crops, and the isolation of a type which will prove resistant to wilt disease. An experiment has been started during the year on the raising of sugarcane seedlings. The results will be awaited with considerable interest; for, if the experiment is successful, it may be possible to discern, both earlier and more accurately, those types which are capable of withstanding the disease and climate of Bihar.

In the Chemical Section, a successful method was worked out during the year for the preparation of dicalcic phosphate from apatite which is found in abundance in parts of Bihar. The study of the movements of nitrates in the soil and the subsoil has been extended to four areas, treated as pasture, fallow, unirrigated cropped land and cultivated land receiving irrigation. The observations made during the year indicate that the distribution of nitrates in the soil, is profoundly modified by the growth of crops and the cultural operations which the field receives. Experiments on the windrowing of sugarcane showed that canes windrowed in the shade for 28 days compared favourably in quality at the end of that time with the crop standing in the field, and germinated well also when planted.

In the Bacteriological Section, it was ascertained that the fixation of nitrogen by algæ alone can take place in India in liquid culture media. Further experiments carried out during the year have shown that by means of composting with sulphur

the natural indigenous source of phosphate in the form of bones can be effectively utilized in place of imported superphosphate. The addition of a small quantity of charcoal to the compost was found to enhance the rate of solubilization. A successful trial was made in certain sugar mills of the use of electrolytic chlorogen (E. C.) for reducing bacterial fermentation of the juice and the formation of invert sugar resulting therefrom. A systematic bacteriological examination of the milk supplied by the Pusa farm gives good grounds for the belief that the production of milk with a content of bacteria falling well within the limits allowed for grade A milk in England demands only ordinary precautions, such as the use of covered milking pails and thorough steaming of pails, cans, etc.

In the Mycological Section, an investigation has been started on a new disease reported from Lower Burma as being the cause of the death of young cinchona plants. The preliminary observations made indicate that neither fungi nor bacteria are responsible for the symptoms which are probably physiological.

The Entomological Section investigated a serious caterpillar pest of coconut in the Andamans. The remedial measures carried out involved the cutting and burning of the leaves affected with caterpillars, the destruction of cocoons and the capture of moths by light traps. Work on the life-history and distribution of Tabanidæ was continued, and the possible transmission of rinderpest through the agency of certain flies was further investigated, in collaboration with the Director of the Muktesar Institute.

In the Agricultural Section, much attention was again given to the trial of various fodder crops. An area of 96 acres of land cropped with berseem gave an enormous yield and afforded excellent grazing for a herd of about 500 cattle from December to May. When the berseem crop was at its best the average milk yield of 78 cows reached the record figure of 18 lb. per head per day, while the annual average of 14·4 lb. per cow per day was higher than the previous year's figure by 1·5 lb. These yields compare well with those of good dairy herds in more advanced countries. From the experience gained in cattle-breeding on the Pusa farm we are now in a position to say (1) that the sire is prepotent in milk production (2) that the dry period of milch cows is shortened by weaning the calves from birth, and (3) that milk yield of dairy cows is largely increased when they are supplied with green fodder throughout the year.

An experiment initiated during the year by the Imperial Dairy Expert with a view to ascertaining whether sterilized milk could be transported from Karnal for sale in Calcutta, a distance of over a thousand miles, proved successful. It is believed that the only way to solve the milk problem in urban centres in this country is to produce milk in rural areas, where the cost of production is comparatively low, and to transport it to urban centres where it can be produced only at a prohibitive cost.

The control of the Sugarcane Breeding Station at Coimbatore has now been transferred to the Imperial Department of Agriculture, and arrangements are being

made to acquire for the station an additional area of land with a view to breeding thick canes and developing the work on thin and medium varieties. About two lakhs of seedling canes were raised in the year under report, a large number of which show very satisfactory vigour of growth. As a result of the distribution of the three Coimbatore canes known as Co. 210, Co. 213 and Co. 214 from Pusa, the area under these varieties in Northern India has risen to 5,000 acres. There was a brisk demand for seed of these varieties in the year under report, and about a lakh of maunds was distributed from various centres.

These Scientific Reports of the Imperial Department of Agriculture indicate that useful work is being done by various experts, and that a body of knowledge is being accumulated which will in course of time prove of the very greatest value to agriculture—India's premier industry.

ORIGINAL ARTICLES

THE LATE PROFESSOR HAROLD MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.

THE news of the tragic death of Professor Harold Maxwell-Lefroy was received with a feeling of keen personal loss by all his old colleagues, his many pupils and his numerous friends in India, where he was so well known and so much respected.

Harold Maxwell-Lefroy was born on 20th January, 1877. He received his education at Marlborough College and King's College, Cambridge, and in 1898 graduated with a First Class in the Natural Sciences Tripos. It was at the University of Cambridge that he came in contact with the great entomologist Dr. Sharp, on whose suggestion he went to the West Indies and joined the Imperial Department of Agriculture. There he started his career as an applied entomologist and laid the foundation of his future reputation. In the West Indies he served from 1899-1903, and did much valuable work.

In April 1903, he was appointed to the Indian Agricultural Service as Entomologist to the Government of India (Imperial Entomologist) and joined at Surat. His headquarters were transferred to Muzaffarpur in October 1904 and to Pusa in May 1905. The present Entomological Section of the Phipps Laboratories was organized under his supervision. He worked in this country for nine years and during this period contributed numerous papers on Indian Entomology and wrote his most useful book " Indian Insect Pests " (1906), and produced his monumental work " Indian Insect Life " (1910). In 1910 his first son died at Pusa, and this sad bereavement was the main cause of his leaving this country. He resigned his post on 30th November, 1912.

On his return to England Maxwell-Lefroy was appointed the first Professor of Entomology at the Imperial College of Science and Technology, where he created a centre of entomological education and research which attracted students from all over the Empire and sent out trained entomologists to every corner of the world.

During 1915-16, Maxwell-Lefroy revisited India as Imperial Silk Specialist and presented a report on the development of sericulture which will for ever remain a source of help and inspiration to those engaged on the extension of this industry.

His services were secured by the Military Department in 1916 and with the rank of a Temporary Lieut.-Colonel he was attached to the Mesopotamia Expeditionary Force, and put in charge of the fly problem.

During 1917-18, he was attached as Entomologist to the Royal Commission on Wheat Supplies.

Born: 20th January, 1877. Died: 14th October, 1925.

LATE PROFESSOR HAROLD MAXWELL-LEFROY.

He was the Honorary Curator of the Insect House, Zoological Gardens, London, for the last 12 years.

Professor H. Maxwell-Lefroy had a very vast and varied experience of entomological work and possessed an enormous store of knowledge based on personal observations, and his death has made a breach in the rank of applied entomologists which it will be difficult to fill.

His magnetic personality affected all who came in contact with him, and he infused in his co-workers and pupils the same enthusiasm for work which he himself possessed. Generations of students at the Imperial College of Science and Technology will hear of his zeal and enthusiasm for Entomology, his sympathy for his pupils and his anxiety to render every possible assistance to those who deserved it. In India, he will be long remembered by his co-workers as a generous officer and a perfect gentleman.

The treacherous darkness of the unknown has claimed many victims from amongst the ranks of scientists and one more name has now been added to the roll of honour. To a warrior death on the battle front is the greatest glory, and what death is more glorious than that of a warrior who, in pursuit of knowledge, falls fighting against the most terrible enemy of mankind—Ignorance, and Harold Maxwell-Lefroy was killed in action on 14th October, 1925.

M. Afzal Husain.

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, MR. J. T. EDWARDS ; *Secretary for Publications*, MR. S. K. SEN).]

IV.

JOHNE'S' DISEASE.

CONFIRMATION of the existence of this disease (sometimes also called bovine paratuberculous enteritis) as a serious limiting factor in some important herds in Southern India has prompted the early insertion, in this series of articles, of the routine instructions now issued by the Institute to correspondents interested in controlling it. The affection is one readily suspected by the history and appearance of the animal, for the symptoms are chronic wasting and diarrhœa which occurs persistently in spite of good feeding and care.

Johne's disease is perhaps the most intractable contagious disease of cattle as far as treatment, preventive or curative, is concerned, for the following reasons :—

(1) The period of incubation, *i.e.*, the time elapsing between the date of exposure to infection and the date when the clinical symptoms exhibited by the animal cause one to suspect the condition, is exceptionally long —six months or even much longer.

(2) A considerable time before distinct clinical symptoms are manifested, infected animals may void the causal organisms in large numbers in their fæces, and spread the infection to other, susceptible, cattle grazing on the same land.

(3) The causal organism is highly resistant, like the other pathogenic acid-fast bacilli, and hence pastures that have once become contaminated may harbour the infection for a long time, probably a year or longer.

(4) Affected animals, especially during the earlier stages of the disease, very often appear to recover spontaneously, and one is therefore tempted to overlook the importance of the premonitory symptoms shown, *viz.*, slight intermittent attacks of diarrhœa and unthriftiness followed by long periods of apparent good health. After the administration of a course of astringent medicine, such as copper sulphate, the apparent recovery of the treated animal is often very noticeable. Yet absolute recovery from the disease has never been proved authentically : relapses almost invariably occur, and hence an animal that

has once become infected is a source of the greatest danger to the healthy cattle in a herd.

Having the above facts now known concerning the disease in mind, the points which have to be considered in devising measures for the control or eradication of the disease are the following :—

i. Diagnosis of infected cattle.
ii. Methods of dealing with the cattle (*i*) clinically affected with the disease, (*ii*) suspected to harbour infection as the result of the application of diagnostic tests.
iii. Methods of preventing contamination of the healthy portion of the herd.

I. Diagnosis.

The greatest vigilance should be exercised in accurately diagnosing the condition as soon as it is suspected in a herd. When definite clinical symptoms are exhibited by any one animal a considerable proportion of the herd may have already become infected, either from this animal or from a common source. Unless steps are taken to check the spread of the disease, clinical cases will then appear from time to time, particularly if the animals have been pastured together on common ground, and from the experience of Western countries the herd is ruined as an economic concern. The following methods may be adopted to diagnose the disease :—

(*a*) *Clinical diagnosis.* The animals affected are nearly always adult cattle, over two years of age. The long period of incubation usually precludes the appearance of clinical changes in younger animals. When such symptoms occur in younger animals they are usually due to verminous infestations. In this country the only other contagious affection of adult cattle that may give rise commonly to slightly similar symptoms is coccidiosis ; tuberculosis, which sets up chronic intestinal derangement in cattle in Western countries, appears to be extremely rare at the present time in cattle in India. The symptoms of Johne's disease in adult cattle are, briefly, intestinal derangement, indefinite in the time of its onset, intermittently observable in the form of short attacks of mild diarrhœa at the commencement, leading progressively to unthriftiness of the animal staring coat, loss of condition in spite of an undiminished appetite, then more or less persistent diarrhœa, with excretion of very fluid fæces, without bloody admixture, emaciation, and finally death from exhaustion. The whole train of symptoms may last several weeks or even months.

(*b*) *Post-mortem diagnosis.* This is usually very easy. If one opens up the terminal portion of the small intestine, next to the ileo-cæcal valve, the mucous membrane is found to be thickened and thrown into a series of prominent ridges or corrugations, somewhat reminiscent of

the surface of the brain. In acute cases that terminate fatally very early after the onset of symptoms these characteristic changes may not be readily detected.

(c) *Diagnosis by microscopic examination.* This is also usually very easy in animals that have died of the disease. All that is necessary is to make a thin smear of the mucous membrane of the last few feet of the small intestine or of the cæcum, stain for acid-fast bacilli in the usual way (by the Ziehl-Neelson method, counter-staining with methylene blue) and examine the smear under a high power of the microscope, with an oil immersion lens, for the presence of small acid-fast rods, which occur characteristically when they are numerous in large clumps or faggots easily recognizable against the dark blue background. In most animals that die of the disease the bacilli are present in smears in large numbers, but in many animals they may be rare and unequally distributed, and so it may be necessary to examine several smears taken from different parts of the mucous membrane within a few feet of the ileo-cæcal valve before convincing evidence is obtained of the presence of the bacilli.

The above methods do not, however, enable one to arrive at an accurate diagnosis during the life of the animal, and hence the following two methods are applicable in this circumstance.

(d) *Diagnosis by microscopic examination of smears taken from the rectum.* In a proportion of clinically affected animals, probably about twenty-five per cent., the causal organisms may be discovered in smears made from the mucous membrane of the rectum. It should be remembered that examination of rectal smears is, therefore, by no means an infallible method of diagnosis, for animals that harbour enormous numbers of organisms higher up in the alimentary tract may fail to reveal any in the rectum. Nevertheless, the method is an invaluable one and may be the only means available for obtaining confirmatory diagnosis in the living animal, without having recourse to slaughter, and it can thus lead to the definite establishment of evidence that the disease actually exists in a herd. A positive result obtained from the examination is definitely confirmatory, whereas a negative result does not necessarily exclude the existence of the disease.

The method recommended for making the smears from the rectum is as follows :—

A piece of mucous membrane, no larger in size than a pin's head, is pinched off between the free edges of the finger nails of the middle, or second, finger and thumb. This operation requires a little dexterity,

After cleansing the finger nails of one hand (the right hand usually) with soap and water the forearm and arm are lubricated with soap and water, the hand introduced into the cavity of the rectum, and the rectal contents emptied. The hand is introduced again after cleansing, and with the tips of the middle finger and thumb held in close apposition like a pair of pincers a minute area of mucous membrane is sharply pinched off well forward in the rectal cavity. A slight difficulty now arises in withdrawing the hand, for the sharp contraction of the anal sphincter would tend to wipe away the fragment of membrane unless special precautions were taken. The thumb and the middle fingers are therefore well flexed so that their tips rest in apposition in the hollow of the palm, while the index finger on one side and the third and fourth fingers on the other are stretched forcibly outwards so as to act as dilators of the rectum during the act of withdrawal and protect the fragment of membrane from interference. The fragment is usually found embedded under a finger nail or may rest on the distal portion of the finger. If the fragment is covered with fæcal material it should be washed gently with clean water. It is then taken up by means of the blade of an old scalpel and well teased out on the surface of one or more glass slides so as to form a moderately thin smear. Smears taken in this way are usually very clean and in a perfect state for examination, while the animal itself is exposed to the minimum of injury. It is well to prepare for examination smears from fragments taken from two or three different parts of the rectum, on account of the unequal distribution of the bacilli. At least one hundred fields of the microscope should be examined in each smear, after staining in the usual way for acid-fast bacilli. The bacilli, when they are found, are usually rare and occur as short delicate scattered single rods. Mistakes frequently occur in the diagnosis of smears containing rare bacilli. Observers are apt to confuse other acid-fast bacilli such as are normally found in the fæces (the so-called "manure bacillus") and even bacterial spores with the true Johne's bacillus. This error can usually be obviated if the decolourizing agent employed in the Ziehl-Neelson method consists of an alcoholic acid solution (such as three per cent. hydrochloric acid in methylated spirit) applied for a long time, about five minutes or longer, instead of the usual watery solution of acid, for the other organisms are usually not "alcohol-fast," although they are "acid-fast." If workers experience any difficulty in diagnosing the smears they are advised to forward them to this laboratory for confirmation.

(e) *Diagnosis by means of special tuberculin* (*avian tuberculin*). It has been found that cattle affected with Johne's disease do not react when

tested with ordinary tuberculin (manufactured from tubercle bacilli of human or bovine origin) such as is used for the diagnosis of tuberculosis infection. They respond, however, when the tuberculin is prepared in an analogous manner from tubercle bacilli of avian origin. A similar product can be prepared also actually from the bacilli of Johne's disease, and this has been proved to provoke reactions in infected animals, but as the manufacture of this product is difficult and the reactions produced by it do not appear to be more pronounced, there is no appreciable advantage in employing it over avian tuberculin, which is more readily prepared. The dose of avian tuberculin recommended (8 c.c.) is somewhat larger than the dose of ordinary tuberculin (3 c.c.) usually employed in testing cattle. The reaction in Johne's disease produced after subcutaneous inoculation displays the same features as those seen in testing tuberculous cattle with ordinary tuberculin, and the test also appears to have the same limitations, but these limitations appear to be even more marked : cattle that are far advanced in the disease, or show distinct clinical symptoms, may fail to exhibit a reaction. On the other hand, the test appears to single out infected animals long before clinical symptoms become manifest. The test can also be employed by the so-called "intracutaneous," or "intradermal" method, in the same way as this method is sometimes employed for the confirmatory diagnosis of ordinary tuberculosis, by injecting a small dose ($\frac{1}{4}$ c.c.) of the concentrated tuberculin into one of the anal folds : the reaction is estimated by the degree of progressive thickening of the injected fold, which is easily measured by comparison with the opposite fold, during the ensuing 48 hours. Another defect inherent to the use of avian tuberculin is that this reagent provokes a reaction in animals affected with ordinary tuberculosis, in much the same manner as ordinary tuberculin does, although ordinary tuberculin does not provoke a reaction in Johne's disease. In Western countries, where tuberculosis is rampant among herds, this is a serious drawback to the employment of the avian tuberculin test for Johne's disease, and it is usually recommended that the cattle should be tested first with ordinary tuberculin to eliminate the possibility of tuberculous infection and then, after an interval of a month, if tuberculosis has been ruled out, subsequently with avian tuberculin for the diagnosis of Johne's disease. In this country, where tuberculosis of cattle appears to be very rare, this drawback to the ready application of the test is greatly reduced, and at the times of the year when animals do not exhibit marked diurnal variations in temperature due to climatic conditions, the test should be easy of systematic application.

[Recent researches at Muktesar have tended to show that the above method of testing with avian tuberculin is not always capable of furnishing unequivocal evidence as to the presence of infection in the tested animal. A considerable proportion of apparently normal animals display suspicious thermal reactions to the subcutaneous test. A method that appears to be more promising is the so-called intrapalpebral (or "I. D. P.") test. This is performed by injecting $\frac{1}{4}$ c.c. of concentrated avian tuberculin into the lower eyelid of one (say, the right) orbit, and, in order to ascertain the possibility of infection with tuberculosis, the same quantity of concentrated ordinary (human) tuberculin into the lower eyelid of the other (the left) orbit. Infection is indicated by the appearance of a persistent swelling, which lasts three days and longer, in the tissues of the right eyelid, and a distinctly smaller swelling in the left eyelid. If the swelling in the left eyelid is more distinct than that of the right, tuberculosis is indicated. A transient swelling, disappearing after 24 hours, is of no significance as regards infection. The test is carried out alone, not concurrently with the subcutaneous or other tests.]

II. Methods of dealing with cattle.

(i) *Clinically affected with the disease.* In Western countries the advice furnished to an owner of clinically affected cattle would be simple :—All cattle showing clinical symptoms, known to be due to the bacilli of Johne's disease, should be slaughtered forthwith to prevent contamination of the rest of the herd ; or, if the carcase of the animal is likely to have any saleable value from the butcher's standpoint, an attempt may be made to restore the bowel conditions of the animal to their normal state by dry stall-feeding and the administration of a course of astringents. An animal which is not far advanced in the disease will then often put on condition in a remarkable manner, and it should be sold for slaughter as soon as it approaches prime condition. In this country, procedure in this manner is precluded, and one would have to eliminate the source of danger by complete segregation of the diseased animal—by housing it, or separating it far away from all possibility of contaminating with its fæces the grazing land of healthy cattle. In the case of milch cows in full profit it might be an economic advantage to stem the progress of the disease in them by dry feeding and the administration of a drench daily consisting of copper sulphate or ferrous sulphate 2 to 3 drachms, dilute sulphuric acid 2 to 3 drachms, and water 1 pint.

(ii) *Suspected to harbour infection as the result of the application of diagnostic tests.* Cattle suspected to harbour infection as the result of having reacted to the avian tuberculin test should likewise be completely isolated. These reactors are, however, very frequently animals in good condition that show no outward signs of any disease

and many appear not to develop clinical symptoms for a very long time afterwards, and on slaughter in order to ascertain the extent of their infection it is often extremely difficult to detect the bacilli of Johne's disease in their intestinal tract. It would be unwise to dispose of these cattle completely from the herd as they might well remain profitable for a very long time. They should be fed as far as possible on dry food and given a prolonged course of astringents as soon as the slightest signs of diarrhœa appear. They should, however, be completely separated from the healthy cattle and on no account allowed to wander on to grazing land of these cattle.

It might be said that segregation of many animals in this way would involve interminable hardship, particularly if contagious abortion existed at the same time in the herd and this disease also necessitated the application of segregation measures. On account of the serious consequences of the persistence of Johne's disease it might be reasonably said that no measure is unduly harsh if it is desired that the herd should be kept together at all. If contagious abortion also exists, Johne's disease should have prior attention, for contagious abortion is a self-limiting disease in that it tends to spend itself in a herd after a lapse of two or three years, and the vaccination measures recommended by this laboratory (see Circular Instructions I. B. L. No. 103) should be adopted whenever segregation measures are impracticable to limit its spread.

III. Methods of preventing contamination of the healthy portion of the herd.

The main source, and perhaps the only serious source, of danger to the healthy animals is the pasture upon which have been voided the fæces of diseased animals, whether clinically affected animals or " carriers " in the incubation stage. Unfortunately, one has no accurate knowledge as to how long contaminated pastures remain infective or what are the best measures for destroying infection on contaminated pastures. It must also be remembered that sheep and goats may become infected with the disease, and so the pastures cannot be left over to these animals for a year or two in the hope that the danger to cattle will die out in the meantime. Horses, however, may be allowed to graze over the land with impunity. Pastures which are notorious for harbouring the infection in Europe are low-lying rich small fields adjacent to the main buildings of the steading, into which the cattle are frequently turned out for grazing at all times of the year. Congestion on pasture land would therefore seem to be an important factor in the spread of the disease. In fact, when Johne's disease has made its appearance it would be a wise course to plough up all the land upon which cattle have been customarily congregated. It is most unlikely that treatment of the pasture with lime would have any appreciable effect in diminishing the infective material on it, for all the acid-fast pathogenic organisms are known to have a very high resistance towards caustic alkalis. The method of pasturing the " clean " animals can best be devised at the seat of the outbreak by

a responsible veterinary officer bearing the above facts now known concerning the nature of the disease in mind and having regard to the resources of the place in this respect. Having laid down a system of pasturing which reasonably precludes all danger to the healthy animals, steps should be taken to ascertain that the system is adhered to most rigorously ; for, accidental infection of one animal with this insidious disease may lead to a repetition of the original state of affairs in the relatively distant future. In order to safeguard against such accidents the avian tuberculin test might be repeated systematically upon all the clean cattle at least once a year.

IV. The possibilities of vaccination.

Experience in Europe covering several years has shown that it is not easy to eradicate the very prevalent kindred affection of tuberculosis from herds by the application of hygienic measures analogous to those described above, and, further, that the risk of rapid spread of the disease is very considerable if infection is inadvertently introduced into the " cleaned " herd. For many years procedures of vaccination against tuberculosis have been known, comprising, as the most commonly described,(i) von Behring's method, which consists in the intravenous inoculation of calves with the human type of tubercle bacilli (a modification tested and described by McFadyean and his colleagues consists in the administration of the avian type), and (ii) Calmette's method, which consists in the administration of the bovine type of bacilli attenuated by repeated subculture over a very long period on artificial media containing ox-gall until the organisms have become incapable of setting up any symptoms of disease on inoculation. The results of the latter method appear to be so promising that it has been taken up for adoption upon request from stock-owners by the Ministry of Agriculture in England. *Pari passu* the arguments underlying the procedure of vaccination, notably by the von Behring method, would indicate that cultures of the avian type should provoke on inoculation the establishment of an immunity towards natural affection with Johne's disease, particularly from what has been stated in regard to reactivity to the so-called tuberculin tests above. Work in this direction has been commenced by the laboratory.

J. T. E.

FLOWERING OF SUGARCANES.

BY

MANMATHANATH GHOSH, M.A.,

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SUGARCANES in flower are not looked upon with favour by a certain class of cultivators. There is a prejudice against such canes arising out of a superstitious belief that flowering of canes in a field brings ill-luck to the owner of the field. The more intelligent of the cultivators seek rationally to explain away the prejudice by observing that the appearance of the flower is an indication of the deterioration of the cane and that the juice therefrom would not yield good *gur* (unrefined, raw sugar). The class of canes generally grown by them either does not flower at all or more rarely produces flowers late in the season when they are already fully mature. Flowering is thus an indication that harvesting has been delayed and should have been done before. These canes when in flower would therefore yield less juice which would also be richer in glucose and consequently the quality of *gur* made from it would suffer. Possibly their experience of flowering cane is limited to only the latter class. Whatever may be the reason, superstition dies hard and this has resulted in some reluctance on the part of the cultivators to look with favour on some of the promising early arrowing varieties which from the point of view of yield and richness of the juice compare very favourably with those they are in the habit of growing.

The Indian cultivators are not alone here and the belief is shared by the cultivators of other countries as well. Earle [1] refers to a similar belief among the Porto Rico cultivators and traces it to the fact that arrowing frequently takes place some time before harvest when, in the event of rain moistening the soil, shooting takes place with deterioration of sugar-content in the arrowed canes. Venkatraman [2] points out that the harm from flowering results chiefly from the stoppage of growth in the main shoot and the sprouting of buds immediately below, resulting in a lower tonnage. and from the fact frequently noticed that the flowered canes develop a pith in the centre. These defects, he contends, may be of some account in the late flowering varieties, but are of no disadvantage in the case of early ones, which if cut soon enough are practically superior to the non-flowering varieties, in consideration of the higher purity and richness of the juice. Labarthe [3] in Peru found that canes in

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[1] Earle. Sugarcane varieties in Porto Rico. Reviewed by Barker in *Int. Sugar Jour.* (1922), XXIV, pp. 236-239.
[2] *Agri. Jour. India,* XVIII, 5, p. 538.
[3] Quoted in *Agri. Jour. India,* XVI, 6, p. 693.

flower contain a juice relatively poor in sucrose and rich in glucose. He also found less juice in the cane and a diminished weight of the crop after flowering so that the yield of sugar was much smaller. This experience is not, however, in agreement with that of most other observers who have found that the sugar-content of the juice remains stationary from the moment of the appearance of the flowers, and though the yield of juice may be smaller, in composition it may be richer in sucrose than in those plants of the same stock in which flowers have not appeared.

Observations made at Sabour with Saretha canes planted in January 1924 and which came into flower in November of the same year, go to show that there is no indication of any decrease of weight in the crop due to flowering nor of any perceptible diminution in the quantity of the juice yield. The table below illustrates this.

TABLE I.

Weight of 50 canes.

Date of cutting	In flower	Not then in flower
	lb.	lb.
16-1-25 . . .	55·5	46·5
26-1-25 . . .	56·9	61·1
6-2-25 . . .	60·7	57·0

Extraction results.

Date of cutting	Canes in flower		Canes not then in flower	
	Percentage of juice on cane	Percentage of sugar on cane	Percentage of juice on cane	Percentage of sugar on cane
19-12-24 . .	62·5	11·67	69·2	12·71
16-1-25 . .	61·2	12·09	55·7	9·63
26-2-25 . .	61·0	11·97	60·0	10·49

Analyses of the juice from samples taken both from the canes already in flower and also from those in which flowers had not then appeared were made from time to time from early December to the end of February. The results prove not simply a remarkable constancy in composition, but a steady improvement in richness and purity for a long time after flowering. By the end of February all the canes in the

field were in flower. It was after this that a deterioration was observed to have set in. The amount of glucose in the juice, which was negligible in the beginning, rose to a measurable quantity towards the end, and the quotient of purity began also to fall (Table II).

TABLE II.

Showing the richness of the juice of Saretha canes (in flower and not in flower).

Date of analysis	In flower or not	Brix	Sucrose per cent.	Glucose per cent.	Glucose ratio	Quotient of purity
12-12-24	a	17·31	16·28	0·041	2·50	95
	b	18·51	17·61	traces	..	95
19-12-24	a	18·37	16·75	traces	..	91
	b	19·77	18·67	traces	..	95
6-1-25	a	18·37	15·97	0·200	1·26	87
	b	19·17	18·21	traces	..	95
16-1-25	a	18·89	17·23	0·490	2·78	91
	b	20·67	19·75	traces	..	95
26-1-25	a	17·69	16·32	traces	..	93
	b	19·70	18·94	traces	..	97
6-2-25	a	17·91	16·65	traces	..	93
	b	20·31	19·95	traces	..	98
16-2-25	a	19·44	18·20	traces	..	94
	b	20·44	19·04	..	..	94
26-2-25	a	18·77	17·48	traces	..	93
	b	21·04	19·63	0·740	3·77	93

a—Sampled from canes *not* in flower.
b—Sampled from canes already in flower.

In point of richness and purity of the juice the canes in flower maintained their superiority over those not in flower. That the latter were not immature canes could be judged from the notable absence of glucose in the juice. There are many factors which influence the purity and the sugar-content of the juice of a cane, notably climate and conditions affecting the growth. A cane growing under conditions which arrest growth attains a striking juice-richness not found under normal conditions. For instance, Khari cane after a long period of drought gave juice containing about 19 per cent. of sugar, while the same cane when the conditions were more favourable to growth gave only 16 per cent. of sugar in the juice. Similarly, Reorha, which is notably a late cane, generally coming into maturity in early March, under water-logged conditions ripened in early December, yielding a juice of remarkable purity and almost entirely free from glucose. The first cane to flower in a clump is usually the best developed, but perhaps because the appearance of flowers is indicative of the arrest of growth, the juice yielded in the tests described was both purer and richer in saccharine content than that obtained from plants which had not yet flowered and in which growth went on as usual.

Another interesting point that was noticed with the flowering canes was the effect of climate on the composition of the juice. In a sub-tropical climate frequent changes are common and influence the growing period of a cane. Sudden setting-in of cold weather gives a set-back to the ripening processes working in the cane which then yields a more watery juice. This retardation Stubbs [1] attempted to explain by suggesting that severe cold killed the cane cells, causing an intermixture of the different kinds of sap which then decomposed. This year there was a cold spell lasting over a week in early January which lowered the sucrose content of the non-flowering canes, but did not seem to produce any effect on the flowering ones. The latter appear to be more able to resist the effects of cold than those which are still growing.

These tests, therefore, prove that the flowering of sugarcane is not necessarily detrimental to the yield of sugar. On the contrary, an early arrowing variety comes into maturity early and by standing on the field without undergoing any change in the composition of the juice until all the canes have flowered lengthens the reaping season, and is, therefore, more favourable to the cultivator who can choose his time for harvest.

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[1] *Louisiana Expt. Stn. Bull.* 37.

FACTORS AFFECTING THE COST OF FOOD FOR MILK PRODUCTION.

BY

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It is easy to understand that alterations in the total milk yield, in the length of the lactation period or in the length of the dry period, will make a difference to the total cost of food for milk production, but such information is of no practical use unless we know the quantitative effect of these factors upon the cost. In an enquiry carried out at Bangalore in 1924 the food consumption of eight cows in milk was accurately determined during a period of 154 days. With these figures it is possible to study the quantitative values of the factors mentioned above. The food consumed by each cow during the entire test of 154 days is shown in the accompanying table.

TABLE I.

Total food consumption (in lb.) in 154 days.

Cow No.	Hay	Silage	Lucerne	Mixture	Ground-nut cake	Brewer's grains
No. 1	1,322	4,028	594	2,008·5	404·3	1,762·0
,, 2	1,216	5,292	260	735·8	384·0	1,762·0
,, 3	955	4,290	579	612·2	334·9	1,762·0
,, 4	868	5,073	594	848·8	360·4	1,762·0
,, 5	885	5,120	594	846·7	359·4	1,762·0
,, 6	900	5,081	594	479·7	285·3	1,762·0
,, 7	1,057	5,581	594	1,120·3	391·9	1,762·0
,, 8	973	5,352	594	840·3	380·3	1,762·0
Cost per 100 lb. in rupees	1-1-2 2-0-7½*	0-12-0	0-8-0	4-15-9	5-11-5	0-13-4

* Two prices for hay of approximately equal quantity are quoted.

It should be mentioned that the cows were given as much hay and silage as they would eat. Concentrates were provided in amounts needed to make up their

full estimated requirements of nutrients, that is to say, the concentrates were given roughly in proportion to the milk yields. In the same table is shown the local cost of each food ingredient. Hay from two sources was available at different times. In quality the two samples did not differ appreciably, but in price one was practically double of the other. Both prices will be considered. From the quantities consumed and with the market rates given, the cost of the different items of each animal's ration has been calculated. The results are shown in Tables II A and II B.

TABLE II A.

Cost (in rupees) of food consumed.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Roughage—								
Hay (low rate) .	14·12	13·05	10·24	9·31	9·50	9·66	11·33	10·44
Silage . . .	30·21	39·69	32·18	38·05	38·40	38·11	41·85	40·14
Lucerne . .	2·97	1·30	2·90	2·97	2·97	2·97	2·97	2·97
TOTAL .	47·30	54·04	45·32	50·33	50 87	50·74	56·15	53·55
Concentrate—								
Mixture . .	99·91	36·71	30·53	42·32	42·22	23·92	55·87	41·90
Cake . . .	23·10	21·91	19·14	20·59	20·54	16·30	22·39	21·87
Brewer's grains .	14·67	14·67	14·67	14·67	14·67	14·67	14·67	14·67
TOTAL .	137·68	73·32	64·34	77·58	77·43	54·89	92·93	78·44
TOTAL RATION	184·98	127·36	109·66	127·91	128·30	105·63	149·08	131·99

TABLE II B.

Cost (in rupees) of food consumed.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Roughage—								
Hay (high rate) .	26·96	24·86	19·47	17·70	18·05	18·35	21·54	19·84
Silage . . .	30·21	39·69	32·18	38·05	38·40	38·11	41·85	40·14
Lucerne . .	2·97	1·30	2·90	2·97	2·97	2·97	2·97	2·97
TOTAL .	60·14	65·85	54·55	58·72	59·42	59·43	66·36	62·95
Concentrate . .	137·68	73·32	64·34	77·58	77·43	54·89	92·93	78·44
TOTAL RATION.	197·82	139·17	118·89	136·30	136·85	114·32	159·29	141·39

In these tables it will be noticed that the cost of concentrate increases rapidly with increase in milk yield. This merely shows that concentrates were fed in proportion to the milk yield, as stated above. The increase in concentrate over roughage is necessary for heavy milkers, because the capacity of the digestive system sets a limit to the amount of food which can be consumed, and if the food is to produce much milk it must provide a correspondingly large amount of digestible nutrients, *i.e.*, the proportion of easily digested concentrates must be increased. In the Bangalore experiment the cost of roughage eaten was more or less the same for all the animals, the highest and lowest figures being Rs. 56 and Rs. 45. The cost of concentrate, on the other hand, ranged from Rs. 137 for the highest yielder to Rs. 55 for the lowest yielder. The cost of food has now to be considered in relation to the milk yield. This is shown in Tables III A and III B.

TABLE III A.

Cost (in rupees) of food per 100 lb. milk (with low priced hay).

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Milk yield in lb.	5,461	3,265	2,887	3,332	3,464	2,452	4,060	3,745
Roughage per 100 lb. milk.	0·866	1·655	1·570	1·511	1·468	2·069	1·383	1·430
Concentrate per 100 lb. milk.	2·521	2·246	2·229	2·328	2·235	2·239	2·289	2·095
Total ration per 100 lb. milk.	3·387	3·901	3·799	3·839	3·703	4·308	3·672	3·525
Order of milk yield	1	6	7	5	4	8	2	3
Cost of roughage	1	7	6	5	4	8	2	3
Cost of whole ration	1	7	5	6	4	8	3	2

TABLE III B.

Cost (in rupees) of food per 100 lb. milk (with high priced hay).

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Roughage per 100 lb. milk.	1·101	2·017	1·890	1·762	1·715	2·424	1·635	1·681
Concentrate per 100 lb. milk.	2·521	2·246	2·229	2·328	2·235	2·239	2·289	2·095
TOTAL RATION PER 100 LB. MILK.	3·622	4·263	4·119	4·090	3·950	4·663	3·924	3·776

The most striking and significant fact brought out by these tables is that the cost of food per 100 lb. of milk is lowest with the high yielding cows.

Looking at the order of milk yield and the order of the cost of the entire ration, we find a very close parallelism. The cost increases quite regularly as the yield decreases. It is worth while at this point to refer to Table IV, column 3, in which the cost of unit weight of each cow's ration is compared. It is seen there that for equal weights the heavy milkers' rations are much more costly. The economy in cost of production shown in Tables III A and III B has, therefore, been attained in spite of the higher cost of the food given to the good milkers. This is a striking testimony to the far-reaching effect which the milk yield exerts upon the cost of food for its production. Rs. 3·39 and Rs. 4·31 per 100 lb. of milk for the highest and lowest yielders are instructive figures. Both tables show further that of the two parts of the ration the cost of the roughage increases very regularly and the cost of the concentrate decreases somewhat irregularly with decreasing milk yields. The extent of these increases and decreases governs the total food cost of the milk.

We have now to compare Tables III A and III B with one another to determine the effect of alterations in the cost of the roughage. In the first place, the rise in price of hay increases the cost of milk to a small extent, namely, by 4 to 6 annas per 100 lb. It is, however, much more important to notice that as the cost of roughage falls the difference in the cost of milk production between high and low yielders becomes less. Comparing cows 1 and 6, for example, we find that decrease in the cost of hay brings down the food cost for cow No. 1 by Re. 0·235. For cow No. 6 the cost is reduced by Re. 0·355. This advantage gained by the low yielding cow is of course due to the fact that a greater proportion of her food consists of roughage. Therefore, a reduction in the cost of roughage makes more difference to the total cost of her ration. These figures show that when roughages are very low in price compared with concentrates, low yielding cows may be kept profitably. Conversely, when the cost of roughage is relatively high compared with concentrates, the high yielding cow becomes more and more profitable. With concentrates and roughages at our prices the high yielding cow is decidedly more economical. The prices quoted for our concentrates are by no means low for India. They must be relatively lower in many localities, and in such places the advantage of the high yielding cow would be still more marked. If rations similar to those used at Bangalore are employed, it is a simple matter to prepare a table of costs on the lines of Table III to effect a comparison. The table gives an instructive insight into the food economy for milk production.

As mentioned above, the most important fact brought out by Table III is that the high yielding cows, to whom a more expensive ration was fed, produced milk more cheaply. This can only be accomplished by a greater milk production from a given quantity of food. To examine this point we must first express all the food ingredients used in the ration in some commensurable unit. For this purpose it is convenient to consider each ingredient as a source of organic matter. We can add together the organic matter contained in each ingredient and thus obtain the weight of the mixed ration expressed in one single quantity—the weight of organic matter

consumed. As the protein content of each ingredient is known, the total protein consumed can also be found by calculation. The ration simplified for comparative purposes in this way is shown in Table IV. Food being valued solely on account of the organic matter it contains, the total cost of the organic matter is the same as the cost of the entire ration, which is given in Table II A. Hence the cost of 100 lb. of organic matter consumed by each cow is found.

TABLE IV.

Total consumed		Cost of 100 lb. organic matter consumed	Consumed per lb. milk	
Protein	Organic matter		Protein	Organic matter
lb.	lb.	Rs.	lb.	lb.
691·9	4,573·7	4·109	0·127	0·837
494·6	3,621·9	3·552	0·152	1·109
449·6	3,087·0	3·654	0·156	1·069
508·7	3,440·8	3·804	0·153	1·033
508·7	3,461·4	3·792	0·147	0·999
417·6	3,096·2	3·508	0·170	1·262
574·1	3,954·0	3·845	0·141	0·974
523·9	3,600·6	3·749	0·140	0·961

Table IV brings out two important points. Firstly, it shows, as might be expected, that the high yielders consumed much more food, expressed as organic matter, than the low yielders. Cow No. 1, for example, consumed 50 per cent. more food than cow No. 4. Secondly, the table shows that the food of the high yielders was more costly. The cost of equal amounts is seen to be practically inversely proportional to the yield. The high yielding cows consumed more and also their food was more costly, weight for weight. How then did they produce milk more cheaply ? It was accomplished by a very much higher milk production per unit of food consumed. Columns 4 and 5 make this quite clear. It is in fact the figures of these two columns that make possible the economical results which were found for the heavy milkers in Table III. The figures of columns 4 and 5, however, raise another question. Are we to conclude from them that a high yielding cow can actually manufacture much more milk from a given amount of material ? The fallacy of course lies in the assumption that all the food consumed is utilized for milk production. This is not so. To begin with, only part of the food consumed is digested. Only the digested food is used and it is used for two main purposes. Part of it is expended

in supporting the animal's vital activities, *i.e.*, for maintenance, and the balance remains for the production of milk. To determine exactly what is required for milk production, we must, therefore, first find out how much food is digested, and from this we must deduct the amount used for maintenance. The digestive capacities of the cows are known, and therefore we can calculate the proportion of the total ration which they digested. The amounts of digested protein and organic matter are shown in Table V.

TABLE V.

Protein and organic matter for maintenance and milk production.

		Digested	Required for maintenance	Balance for milk	Used per lb. milk
		lb.	lb.	lb.	lb.
No. 1	Protein	420·7	98·3	322·4	0·059
	Organic matter	2,630·0	1,068·0	1,562·0	0·286
No. 2	Protein	295·8	103·1	192·7	0·059
	Organic matter	1,970·3	1,101·8	868·5	0·266
No. 3	Protein	279·6	96·7	182·9	0·063
	Organic matter	1,867·7	1,055·7	812·0	0·281
No. 4	Protein	300·1	76·3	223·8	0·067
	Organic matter	1,892·5	901·7	990·8	0·297
No. 5	Protein	294·1	86·4	207·7	0·060
	Organic matter	1,862·2	978·7	883·5	0·255
No. 6	Protein	240·1	89·3	170·8	0·069
	Organic matter	1,752·5	1,000·8	751·7	0·307
No. 7	Protein	354·2	98·6	255·6	0·063
	Organic matter	2,253·8	1,069·5	1,184·3	0·292
No. 8	Protein	314·8	92·0	222·8	0·060
	Organic matter	2,056·0	1,020·9	1,035·1	0·276

The maintenance requirements of cattle have been determined by experiments with bullocks. The bullock results can be employed for calculating the maintenance requirements of our cows. The figures obtained by this calculation are shown in the second column of Table V. By difference the balance remaining for milk

production is found. This is shown in the third column. Dividing this by the milk yield we obtain finally the amounts actually used for the production of 1 lb. of milk. Table V contains important information. It shows, in the first place, that the maintenance requirement absorbs a large proportion of the food digested. One-third to one-fourth of the protein goes to maintain the animal, and of the organic matter in many cases more than ½ is expended in the same way. The figures show in a striking manner that economy in milk production depends upon the ability of the cow to consume more than a maintenance ration. The more she can consume above this amount, the greater will be the proportion available for milk. The figures for cows 1 and 6, the best and worst milkers respectively, make the point clear. No. 1 digested 2,630 lb. of organic matter. For maintenance she required 1,068 lb., which left a balance of 1,562 lb. or nearly 60 per cent. of the digested food for milk formation. No. 6 digested only 1,752·5 lb. Her maintenance requirement was lower than that of No. 1, and yet the balance available for milk production is only 751·7 lb. or 43 per cent. of her digested food. Another important fact we learn from the figures of the last column is that the net food requirement for the production of 1 lb. of milk is not related to the milk yield. It is found to be much the same for all the animals. The differences are small on the whole and can be largely accounted for by the fact that the maintenance requirement is hardly ever exactly equal to the computed standard amount. The figures show, therefore, as well as can be expected, that the net requirements for milk production are approximately the same for all cows. This statement requires some qualification. In the first place the quality of the food makes a difference, because, according to quality, more or less energy is expended in digestion. Cow No. 6 received decidedly lower quality of food than any of the others (see proportion of roughage to concentrate in Table II) ; her higher requirement per lb. of milk may be partly explained in this way. The quality of the milk produced also makes an appreciable difference. Rich milk requires more nutrients for its production than poor milk. Another point deserving mention is that, if we overlook minor irregularities, the conception of the maintenance requirement, for which standards have been obtained from bullocks, clears up the question of milk production satisfactorily. The figures for maintenance derived from bullock experiments are therefore of great service.

Finally, it has to be observed that accurate figures for the net requirements for milk production (column 4) can be expected only when cows are giving heavy milk yields. With low yields the errors in estimating maintenance allowance and the utilization of food for body development all fall on the small balance available for milk production. For this reason the Bangalore experiments were carried out during the period of high milk yield.

One of the most important factors influencing the cost of milk production remains to be dealt with, namely, the length of the lactation period and the length of dry period. At this initial stage of the work at Bangalore it was not possible to keep a strict account of the food of these cows for the whole time, but we know the length

of the lactation period, the total dry period and the total milk yield. This information is contained in Table VI.

TABLE VI.

Months in milk	Months dry	Maintenance days	Total milk	Daily digested organic matter for maintenance	Digested organic matter per lb. milk
			lb.	lb.	lb.
11	1	365	8,385	6·935	0·286
8	4	365	3,474	7·155	0·266
10	4	425	4,222	6·858	0·281
11	4	455	5,315	5·855	0·297
8	2	305	5,266	6·358	0·255
7	3	305	3,044	6·499	0·307
7	3	305	6,685	6 945	0·292
11	3	425	7,220	6·629	0·276

With the aid of the food requirement figures obtained in the earlier part of the work (columns 5 and 6 of Table V) an estimate can be made of the food consumption for the entire lactation and dry periods. From these figures the cost of milk production for the entire lactation cycle is worked out in Table VII. For comparison the figures obtained during the high yielding stage (Table III A) are added.

TABLE VII.

Dry period days	Total period days	Organic matter required for maintenance for entire period	Organic matter required for milk production	Total required for maintenance and milk	Cost	COST PER 100 LB. MILK: Entire lactation cycle	COST PER 100 LB. MILK: High yielding period
		lb.	lb.	lb.	Rs.	Rs.	Rs.
30	365	2,531	2,398	4,929	346·7	4·134	3·387
120	365	2,611	924	3,535	228·5	6·577	3·901
120	425	2,914	1,187	4,101	240 8	5·704	3·779
120	455	2,664	1,581	4,245	286·9	5·398	3·839
60	305	1,938	1,343	3,281	226·0	4·293	3·703
90	305	1,982	933	2,915	175·7	5·772	4·308
90	305	2,118	1,950	4,068	269·1	4·025	3·672
90	425	2,817	1,995	4,812	308·9	4·279	3·525

Comparing these two sets of costs it is seen that the length of the lactation period is a very important factor. The true cost based on the length of the lactation cycle is in every case very much higher than the cost found for the milking stage. It is interesting to notice, however, that though the lactation periods varied very considerably in length the order of cost per 100 lb. milk is still the same as the order of milk yield, the high yielders producing milk at the lowest cost and the low yielders at the highest cost. That is to say, economy of production depends first and foremost upon milk yield. The length of the lactation cycle is also an important factor, but generally the total yield has more effect upon the cost. The two sets of figures show clearly the effect each of these factors has had on the cost of milk production by the individual animals. As the end of the lactation period exerts a marked effect upon the cost, observations covering the complete lactation cycle are desirable.

TRACTORS IN THE NORTHERN CIRCLE OF THE CENTRAL PROVINCES.

BY

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In the north of the Central Provinces, a very large area of land has gone out of cultivation owing to the deep-rooted and obnoxious weed *kans* grass (*Saccharum spontaneum*). It is impossible to state with any degree of accuracy the exact area of culturable land thus rendered useless, but in some parts the invasion of the weed has had a marked influence on the general prosperity. In the Settlement report of the Saugor District effected during the year 1911-16, Mr. Corbett says :—" The climate is the cultivators' worst enemy. Next is the *kans* weed (*Saccharum spontaneum*) which often follows in seasonal calamity and retards recovery. *Kans*, as it has been remarked, is the result rather than the cause of misfortune. It appears at once, probably by seeding, whenever cultivated black soil is not properly weeded ; that is, when it is sown broadcast with *kharif* or when it is left unsown altogether, or again, when monsoon ploughings are neglected or prevented by continuous rains. *Mund* soils seem peculiarly susceptible to attack. In its early stages, *kans* can be successfully fought by hard ploughing. But when once it has firmly taken hold, it cannot be eradicated by ordinary implements. ' It sends down its roots,' wrote Colonel Maclean, ' to an amazing depth and forms a complete reticulation of roots throughout the entire extent of land covered by it.' Cultivation is then abandoned. But after 8 to 12 years of fallow, *kans* dies out of itself and does not reappear until the land has again been cultivated and again neglected. The Khurai Tehsil is never quite free from *kans* and has been periodically overwhelmed by apparently irresistible invasions. There is a theory there that land which is exhausted by continuous wheat cropping, is mysteriously infected. But this easy explanation cannot, in my opinion, be sustained. In the stiffer soils of Khurai it is, no doubt, more difficult to eradicate *kans* in its earlier stages. But it is slovenly cultivation that establishes permanent seed reserves and allows *kans* to spread. In the rest of the district, *kans* only became formidable in the famines, when loss of population, scarcity of seed and mortality amongst plough cattle reduced the standard of agriculture to the Khurai level ; and as normal conditions were restored and good cultivation reasserted itself, it was rapidly reduced to its former insignificance. The ultimate solution of the Khurai problem is increased pressure of population, which will compel the intensive cultivation that the strong soil requires."

In the 10 districts comprising the two divisions of Jubbulpore and Nerbudda, the average area of land "out of cultivation" for the three years 1921-22 to 1923-24 was 2,187,159 acres out of a total area in the holdings of 5,558,240 acres or 39 per cent. A considerable proportion of this fallow area is occupied by *kans* grass, and very little can be done by the cultivator with his crude implements to bring back infected land into a state fit for cultivation. The reason for the dying off of the *kans* after 8 to 12 years, quoted by Mr. Corbett above, is probably because it becomes root-bound, and a cultivation with a country plough at this stage would only make matters worse by giving the remaining plants room to develop.

Some doubt seems to exist as to the method by which *kans* grass propagates itself in infecting new areas, several authorities being very sceptical about the seed being the means of doing so. In order to test whether the seed was vital, germination tests were carried out on the Powarkhera (Hoshangabad) farm three years ago, and 95 per cent. germination was obtained. The seedlings are very delicate and are very easily destroyed either by heavy rain or by implements. This probably explains the waves of invasion in Saugor District, as the cultivators could not give the necessary cultivation to their fields. Once established, the *kans* sends out strong underground stems, and when this stage is reached, eradication becomes difficult with the country implements.

In some parts of the Central Provinces, *kans* is dug out by hand at a cost of about Rs. 80 an acre, but, as with all other means of eradication, careful after-cultivation is necessary to keep the weed under control.

Within recent years, the Agricultural Department has spent considerable time on the question of eradicating *kans*. The small Monsoon plough has proved very beneficial, and the department has been demonstrating its use for some years. Plots of land overrun with the grass are being taken over by the department for two years, and after ploughing with the Monsoon plough in the hot and rainy seasons, the land is put down to the ordinary crops of the tract, *viz.*, cotton, *juar* (Sorghum), wheat or gram. By this method, it is found that about 75 per cent. of the *kans* is killed, and great care has to be taken to prevent the remaining 25 per cent. from gaining the upper hand. In the second season, the land is again ploughed and cropped and is then handed back to the owner in a clean condition.

In 1923, two International 15-30 H. P. tractors were purchased by the department for work on *kans* eradication. The ploughs used were 3-furrow self-lift International ploughs with digger bodies.

Two years previously, at a demonstration of tractors given in Jubbulpore, it was found that it was not necessary to go to a great depth to kill the *kans*. It was at first thought that it would be necessary to plough to 12 inches deep and the first ploughings done were at this depth. It was found, however, that even at a depth of 7 or 8 inches the *kans* was killed, provided that the soil was inverted to expose the underground stems to the sun and to smother the roots still in the unploughed subsoil. In the fields ploughed it was found that only in the open furrows did the

kans come up again during the following season, no matter at what depth the ploughing was done.

Benefiting from the experience gained in the previous demonstrations, the department undertook to plough *kans*-infected fields to a minimum depth of 8 inches at a rate of Rs. 25 per acre.

Work was started in December 1923 in land belonging to Diwan Bahadur Seth Jiwan Das in a village six miles from Jubbulpore. An area of 100 acres was handed over for ploughing. The work done was very good, the soil being well turned up, and the *kans*, which at the start almost hid the tractors and ploughs, disappeared beneath the furrows. Ploughing continued till April when the soil became so hard that both the tractors broke down, but a total of 313 acres was completed before this happened.

In December 1924 only one tractor was ready for work, as spares had to come from America and had not arrived. At the beginning of the ploughing season, a requisition for only 12 acres to be ploughed had been received by the department in one village five miles from Jubbulpore, but before leaving that village, 99 acres were turned up. So successful was the work that requests came in from all over the district for the tractors, and when finally it was decided to stop operations in April owing to the hardness of the ground, only 202 acres out of nearly 1,000 for which orders were received had been ploughed with the one tractor.

Breakdowns were frequent, but as we could fall back on the parts of the derelict machine, the time lost was not very great. At the close of the ploughing season, the spares were received from America just in time to send the machines to Nagpur where they were required for the cultivation of the College Farm.

The total area ploughed in the two seasons was 515·26 acres in 1,235 running hours. In addition, 74 hours were spent in belt work, driving a threshing machine on the Government farm at Adhartal.

The costs involved were as follows :—

	Rs.	A.	P.
Cost of two tractors, 15-30 H.P.	10,511	8	0
Cost of 3 ploughs	1,884	0	0
Insurance and freight	292	13	9
TOTAL	12,688	5	9
Cost of spare parts used	608	15	6
Cost of repairs	655	9	9
Cost of petrol, kerosine and oil	3,512	6	9
Depreciation at 20 per cent. for 2 years	5,075	5	6
Bonus given to drivers at As. 4 per acre	128	12	0
Pay of drivers and overseer for 12 months at Rs. 35 and Rs. 75, *i.e.*, for 6 months each ploughing season	1,740	0	0
TOTAL	11,721	1	6
Income paid into the treasury	12,881	8	0
Profit to Government	1,160	6	6

The soil ploughed was all *kabar* I and II which are stiff clays containing up to 75 per cent. of clay on analysis. In the hot weather these soils bake hard and are very difficult to penetrate, though they are easier to plough when there is a thick crop of *kans* growing on them than when absolutely bare of covering. The land after ploughing in the hot season consists of a large number of big clods weighing from a few pounds up to nearly 1½ maunds.

Very wide "feerings" were adopted in order to reduce as far as possible open furrows which were, in small fields, only allowed at the edges near the *bunds* when finishing off the fields by ploughing round.

Practically all the fields had been lying fallow since the big famines at the end of the 19th century and were bringing in nothing to their owners.

Crop-cutting experiments were made on some of the fields ploughed in December 1923 and which were cropped last *rabi* season with wheat, with the following results.

	Variety of wheat	Outturn per acre lb.
On tractor ploughed land	A088	650
On ordinary land	A088	700
On tractor ploughed land	A013	660
On ordinary land	A013	750

At 15 lb. a rupee, the income per acre amounts to Rs. 43-8. Deducting the cost of initial cultivation, *viz.*, Rs. 25, the balance of Rs. 18-8 very nearly pays for seed and the other operations, so that in the second year the land becomes once more remunerative.

There is under consideration at present for use in the stiff soils of the Northern Circle a scheme for the purchase by Government of a steam tackle. If this is sanctioned, the ploughing charges will be reduced considerably and the tackle will find plenty of work for the six months of the year during which ploughing can be performed. Even at the comparatively high rate of Rs. 25 an acre, there was more than enough land to keep two tractors going, and when the price is reduced the demand will be very great.

PLAIN AND REINFORCED CONCRETE CONSTRUCTION SIMPLIFIED.*

BY

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THE use of cement concrete in constructional works in India has not reached that state of development which has been attained in Western countries, the chief reason being the difficulty and expense involved in obtaining a high grade cement from abroad. During recent years, however, the manufacture of high grade cement has been successfully undertaken in India, and every year cement concrete is being used more and more for general constructional purposes, in which cheapness, permanence, strength and freedom from the necessity of frequent repairs, are the main desiderata. In such structures as water tanks, retaining and other walls, pillars, piers, abutments, grain bins, foundation wells, etc., the advantages of the patent "Simplified" method † of construction are most apparent.

Prior to the introduction of "Simplified" construction, the great drawback in plain or reinforced concrete construction was the time and expense involved in the preparation of forms or moulds to receive the concrete, and the further expense in dismantling and removing these moulds after the completion of the structure. If several structures of one pattern are to be made, then the moulds—if of timber—generally require many repairs and renewals prior to each operation; particularly is this the case in India, where great variation of temperature does more damage to timber moulds than in countries having a more equable climate; but, when a large amount of repetition work has to be executed, then the forms are very substantially made and metal is largely, or even entirely, used in their construction, thus adding considerably to their initial cost, but reducing the maintenance cost. With many of the forms in use there is great difficulty in keeping the reinforcing bars in their correct positions, this difficulty is most marked in the construction of walls, etc., of one foot, or less, in thickness, and when the mould used is several feet in height; then the reinforcing bars are often displaced during the operation of filling the concrete, with the result that the requisite covering of concrete over the reinforcing bars is either less or more than it should be. Protection from corrosion of the steel reinforcing bars necessitates a covering of concrete over them of one to two inches

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* The greater portion of this article and the illustrations appeared in *Indian Engineering*, dated 2nd May, 1925.

† The system of concrete construction explained in this article is completely covered by Patents.

in thickness, according to circumstances, and this requirement is made use of in "Simplified Construction" to eliminate the costly timber and metal moulds or forms required in a large variety of reinforced concrete structures.

SIMPLIFIED CONSTRUCTION.

In this patented method of reinforced concrete construction, that portion of the concrete which serves as covering material for the reinforcing bars is made use of to form the mould for the structure in the following manner. Concrete shapes of I section are moulded; the thickness of the flange being equal to the required covering over the reinforcing bars, the overall dimensions of the I shape are such that one vertical and one horizontal reinforcing bar is in each shape or block; the web joining the flanges of each I block contains a groove close to the flange for the reception of the horizontal reinforcing bar. For light works in reinforced concrete, a convenient size for the outer face flange of a block is nine inches long and six inches in depth; this permits of horizontal reinforcing bars being at six-inch intervals and the verticals being at nine-inch intervals. For mass concrete work, or for walls of moderate thickness, it is convenient to make the I blocks with one flange larger than the other, as this system permits of standard blocks being used for a large variety of work.

The form of the blocks or shapes, and the method of employing them, will be evident from the accompanying illustrations. Fig. 1 shows in plan the form of

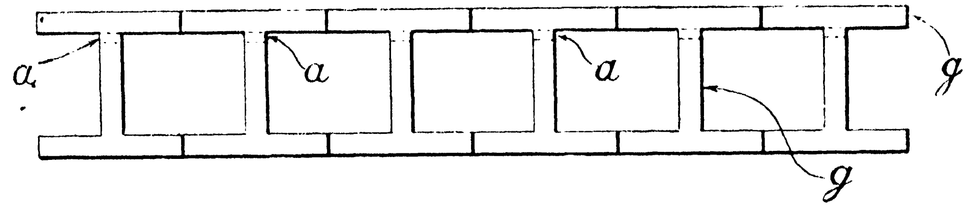


FIG. 1. Type of concrete forms suitable for thin walls, tanks, etc.

blocks used in thin walls of six to twelve or fifteen inches in total thickness, a groove being moulded in the web of each block at A, to take the horizontal reinforcing bar. Fig. 2 is a repetition of Fig. 1 with the addition of a second course of blocks, the

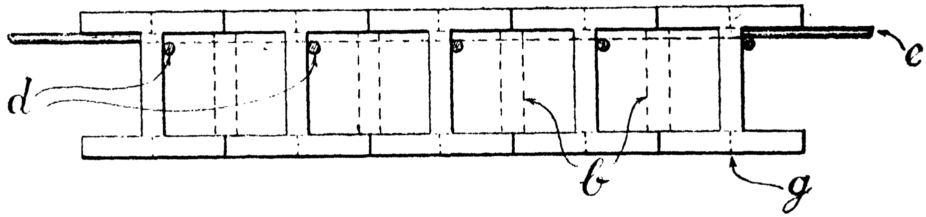


FIG. 2. Similar to Fig. 1, the dotted lines indicate the position of the form in the lower course.

positions of which are indicated by the dotted lines representing the lower course, the full lines representing the upper course; in this figure the horizontal reinforcing bar is shown in dotted lines at E, the vertical reinforcing bars being indicated at D. Fig. 3 shows a front or back elevation of a wall, the positions of two of the

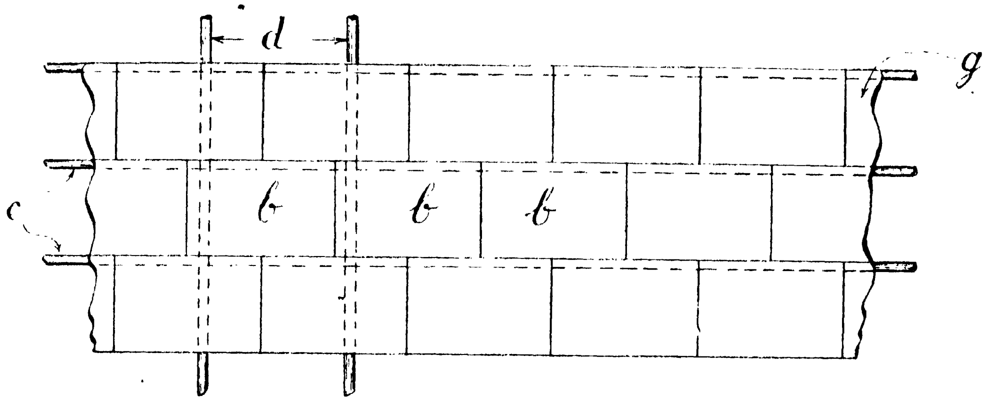


FIG. 3. An elevation of wall built with the forms.

vertical and two of the horizontal reinforcing bars being shown in dotted lines at D and E respectively. From FIGS. 2 and 3 it will be obvious that the blocks are readily placed in position and that no "stringing" over the reinforcing bars is required. For all circular work such as water or oil tanks, grain bins, wells, foundation piers, pillars, etc., the inner flange of each block is cast slightly shorter than the outer flange; this is done in order to allow for the difference in circumference of the circles formed by the outer and inner faces of the structure.

For mass concrete work, which in ordinary circumstances would require a mould for one face only, as for example a retaining wall, or for thick walls, etc., the form is cast in the shapes shown in Figs. 4, 5 and 6, in which the inner flange is made considerably shorter than the outer flange. It is convenient to make the inner

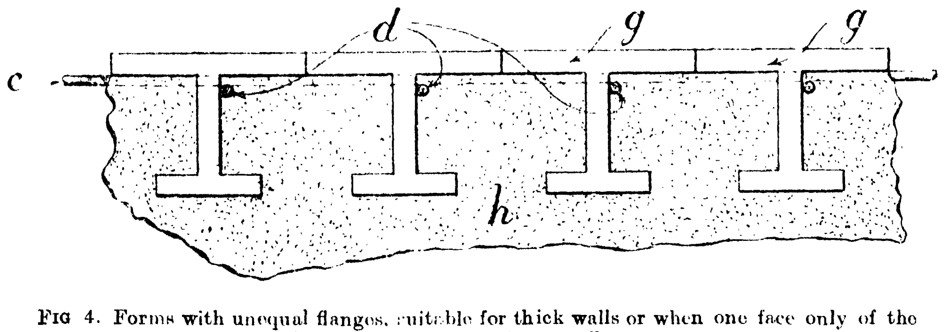
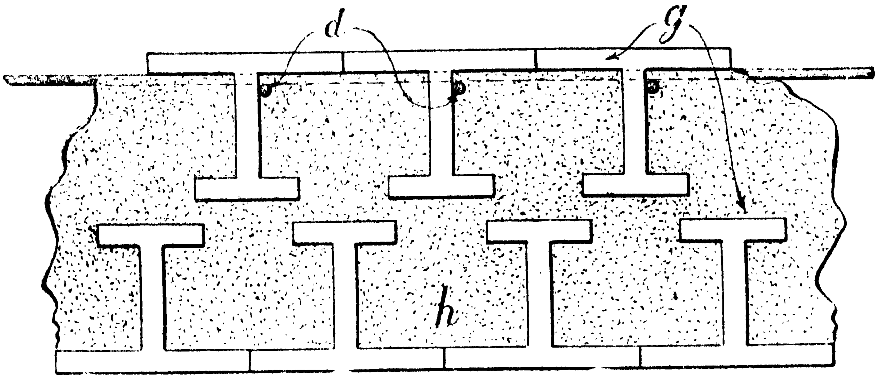
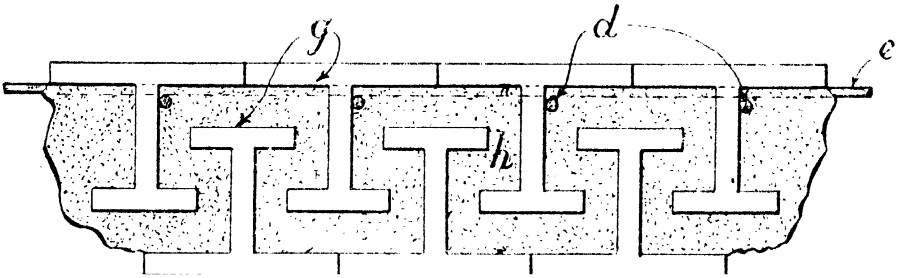


FIG 4. Forms with unequal flanges, suitable for thick walls or when one face only of the wall is required as in retaining walls, etc.





FIGS. 5 & 6 illustrate the method of construction of walls of different thicknesses with standard forms of unequal flanges.

NOTE :—Horizontal reinforcement is shown at e and vertical at d in all figures.

flange one inch greater than half the length of the outer flange, for, by doing so, the ends of the inner flanges rest on the ends of the inner flanges of the blocks in the course immediately below and no building skill is required to place the forms, or blocks, in position.

MOULDING.

The concrete forms required are very rapidly and economically cast or moulded on a hand machine specially designed for the purpose. The machine is comprised of three essential parts, (*a*) the body, which consists of a box of four sides only, mounted at a convenient height on a stand, (*b*) a sliding frame on which is placed the bottom of the box, and (*c*) a hand lever for operating the sliding frame. The mould proper, from which the required forms are cast, is conveniently made from wood, the outer dimensions of the mould fitting the box of the moulding machine, the interior of the mould being made with openings of the shape of the forms to be cast ; this mould is retained in position in the box by lugs on its upper surface and can be rapidly exchanged for another mould when it is desired to cast shapes of a different pattern.

PLATE II.

FIG. 1. Moulding machine, the mould being filled. The depressed lever keeps the mould bottom in contact with the mould.

FIG. 2 Moulding machine. The lever has been raised, thus depositing the mould bottom (with the two concrete casts thereon) on the trolly.

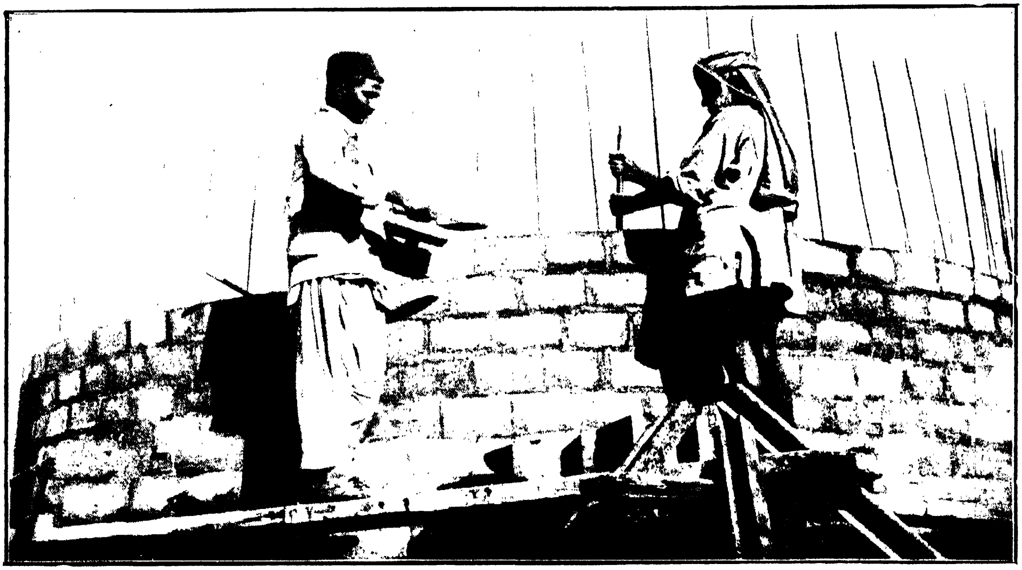


FIG. 1. Circular water tank under construction. The wall is nine inches thick.

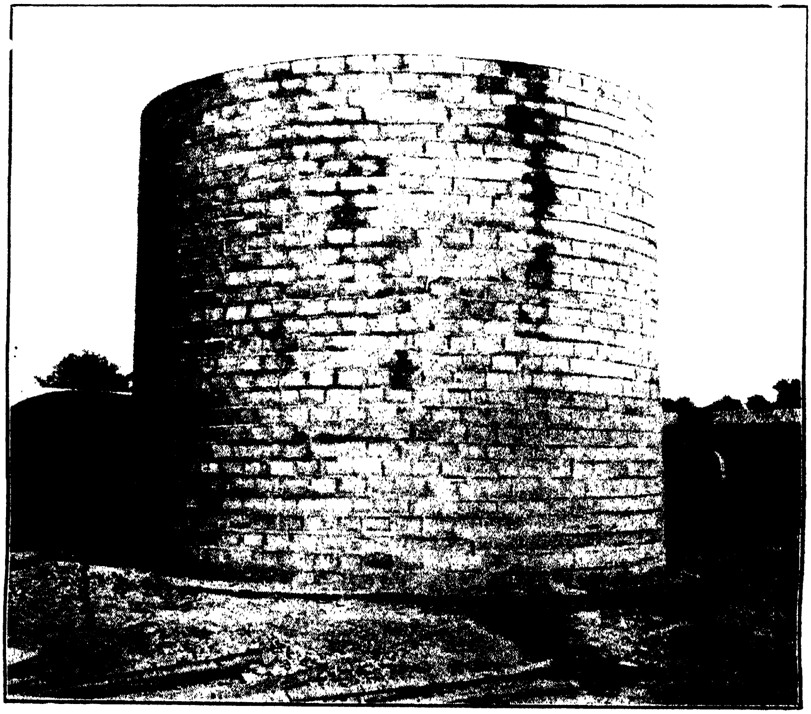


FIG. 2. Circular water tank completed. It is 15 feet in diameter and contains 15 feet depth of water.

The process of making the cast is as follows:—

A mould bottom which consists of a plain piece of wood having two holes in it to register on pins in the sliding frame is placed on the sliding frame; the lever is then depressed and held in that position by a clip; the depression of the lever brings the mould bottom up into contact with the mould box. The mould is now filled with concrete, after which the lever is raised thus lowering the mould bottom with the cast piece or pieces of concrete thereon, the mould bottom is lowered on to a trolly placed immediately under the moulding box and this trolly can now be pushed clear of the moulding machine, the mould bottom—with the casts thereon—removed and set aside to harden; a new mould bottom is immediately placed on the frame and the lever depressed, thus bringing the bottom up ready for the next casting. The whole operation of moulding is extremely rapid and with the machine shown in the accompanying illustrations (Plate II) one mason and four coolies mixed the concrete and moulded 144 blocks per working day of eight hours. The work was entirely new to the men; with a little practice the output could have been much improved, but the output obtained represents a very low cost for the labour required to produce the blocks.

Two illustrations (Plate III) are given of a reinforced concrete water tank fifteen feet in diameter and containing fifteen feet depth of water; one of the illustrations shows the tank in course of construction and the other shows the completed work. The overall thickness of the wall is nine inches only and the reinforcing bars—of which there is one horizontal to every layer of blocks, and one vertical to every block—take the entire stress due to the water pressure. The tank was completed without the use of timber or other shuttering of any kind, and the cost of construction shows a very marked saving over the old method in which timber or other shuttering is used. The blocks used were composed of a nine to one concrete, that is, one part cement to nine parts aggregate, and this mixture proved quite satisfactory for the work.

There are many forms of construction for which the method described can be adopted, and it is not always necessary to fill in the void left between the I shapes; in other words, hollow wall construction is as easy as solid construction, and for house building and similar work, reinforcement would not be necessary; in certain other classes of work the voids may be filled with a poor mixture of concrete or even with a lime concrete.

COMPOST.

BY

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One of the many items of work that the Department of Agriculture has been advocating for several years in the north of the Central Provinces is the utilization of weeds, etc., as manure in the form of compost.

In some of the light soil tracts of Jubbulpore and Damoh Districts, the opening of Government irrigation tanks has been of doubtful benefit to the prosperity of the cultivator. The land, in the past, bore one crop of broadcast rice in a year, and every now and again a forced fallow was caused by shortage of rainfall. Since the opening of irrigation works the cultivators have been taking double crops of rice and wheat without applying manure to their land, with the result that they now complain of not being able to obtain even a fair crop of rice.

In order to overcome this, the department has been demonstrating on its domonstration plots and in the fields of the cultivators the conservation of cattle dung, urine earth, sann-hemp as a green manure, *tarota* (*Cassia Tora*) cut from the village sites as a green manure or put into a compost heap, and the making of compost from all the weeds and *katchra* removed from the fields in weeding and usually left on the *bunds*.

The practice was first tried on the Adhartal farm, Jubbulpore, in the year 1918-19. All the weeds from the rice fields were collected and treated as follows. A thick layer of one foot of weeds was spread out on the ground, sprinkled over with quick-lime, and then covered over with a layer of moist earth ; on top of this another layer of weeds, lime and earth and so on until the whole of the weeds was covered up. After being allowed to decay for 3 or 4 months, the heap was turned to allow of better decomposition.

During the cane-crushing season, all the megass from the mills was added to the heap, but as this manure was to be used for sugarcane, it was deemed advisable to discontinue adding the megass owing to the danger of disease, and now only weeds are made into compost. The megass is spread direct on the rice fields where it soon decomposes.

Recently the application of lime to the heap has been discontinued owing to its cost, and the heap is now kept for two years in order to allow any weed seeds to germinate in the succeeding monsoon and so prevent the reinfestation of the fields.

On the Adhartal farm, about 450 cartloads of compost and megass are obtained

every year. This means a considerable quantity of manure added to the farm stock.

Experiments were carried out in 1920-21 and 1921-22 to find out the value of compost as a manure, and the results show that it is every bit as good as farmyard manure, if not better.

		lb. per acre
1920-21—		
Paddy No. 17	No manure	1,090
Ditto	Compost	1,170
Dilbaxa paddy	No manure	610
Ditto	Compost	1,060
1921-22—		
Paddy No. 17	No manure	1,350
Ditto	Compost	1,720
Dilbaxa paddy	No manure	1,430
Ditto	Compost	1,830

		mds. per acre	lb. *gur* per acre
1920-21—			
Sugarcane—Pounda	Cattle dung	250	5,818
	Compost	250	6,545
Yuba	Cattle dung	250	6,560
	Compost	250	6,720
Gilman's red sport	Cattle dung	250	6,000
	Compost	250	7,000

One part of non-experimental Khari cane was heavily manured with compost in order to fill up some uneven parts in the field and the outturn was at the rate of 52 tons of stripped cane per acre.

Each Government farm in the Northern Circle has now a compost heap as part of the farm economy, and though few cultivators make such heaps, many of them utilize the waeds and apply them along with their cattle dung.

NOTES ON CANNING MANGOES.

BY

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At present there seems to be a growing demand for canned and preserved fruits in Indian markets. Many queries come to the station for methods of canning mangoes, pineapple, etc. It is with a view to supply correct information on the subject and at the same time to introduce the practice of canning and preserving fruits and vegetables among individuals trying to start a business on a cottage industry scale, that a series of experiments have been carried on in canning fruits and vegetables at the Jorhat laboratory for the last two years. As a result of successful experiments, a bulletin was published by the Department of Agriculture, Assam.[1] Besides, 8 students were allowed in our laboratory for three months in 1924-25 to get a training in the art of canning and preserving.

Publications on canning and preserving are very rare in India, and more so the experimental work on this line. In his "Book of Mango," Dr. Burns, Economic Botanist to the Government of Bombay, recorded some experiments in canning mangoes[2], and that seems to be the only attempt of its kind published in India up-to-date. Considering the present poor status of our fruit industry in India and specially the waste of fruits in season, it may not be out of place here to mention that our fruit industry will never be a commercial success until the surplus commodity is utilized by canning and preserving both on cottage industry and commercial scales. It is for this reason experiments on this line seem to be very inviting. In this short paper an attempt will be made to discuss the results of our experiments on canning mangoes at the agricultural laboratory at Jorhat.

Assam mangoes are very poor in quality. There are no standard varieties known in the market. The mangoes in this part of the country are very sour and mostly affected by mango weevils. Ripe local mangoes are seldom found in the market in good condition. Mango orchards are very rare and no attempt has yet been made to improve the cultivation of mangoes in Assam.

In the experiments on canning mangoes, the fruits were washed, peeled and cut carefully and were then canned in sugar syrups of different strengths. The strength of the sugar was measured in degrees for which a Brix saccharometer was used.

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[1] *Assam Dept. Land Records and Agri. Bull.* 1 of 1923 (reprinted).
[2] *Bombay Dept. Agri. Bull.* 103 of 1920.

Pure cane sugar was used in making the syrup, the percentage of which varied from 12·5 to 60 per cent. The sugar used in canning mangoes acts as a preservative and improves the flavour of the canned product. In addition to sugar, other materials, such as brine, vinegar, brandy, water, and mango juice extracted from ripe soft mangoes, were also tried separately.

As for the containers, both glass jars (pint and quart) and solder-top tin cans (½ lb. and 1 lb.) were used for experimental purposes. The cans were obtained from the Bengal Canning and Condiment Works, Ltd., and the jars from Messrs. Hall and Anderson, Ltd., Calcutta. In soldering the tin cans no special canning outfit was used except a solder steel and a tipping steel. Apart from this, the ordinary cooking utensils, such as knives, sauce pans, spoons, etc., were used in preparing the fruits for canning.

Sterilization is the main problem in canning fruits. If the containers are not properly subjected to a certain degree of temperature for the required time needed for sterilization, they will either "spoil" (ferment) or give a disagreeable cooked taste to the canned product. In our experiments with fruits, the containers were sterilized at 100-101°C. in a soup digester, and they were sterilized at that temperature for 20-35 minutes as need be. If the fruits are sour and properly handled, sterilization for 15 minutes is quite sufficient. It must be admitted here that the effects of different temperatures could not be tested satisfactorily for want of a steam pressure sterilizer. However, the results obtained are of some interest from the economic point of view, especially to those who are interested in the development of cottage industries in India.

In order to explain clearly the nature of different treatments and the time required for sterilization of the fruits used in the experiment on canning mangoes, the results have been tabulated as follows.

Serial No.	Nature of mangoes	Date treated	Date examined	Blanching	Treatment	Time of sterilization	Results	REMARKS
1a	Sliced green (sour)	April 17, 1923	December 25, 1923.	2 minutes .	12·5 per cent. syrup.	15-20 minutes .	Sour, flat taste .	Only good for culinary purposes.
b		Do. .	Do. . .	Do. . .	25 per cent. syrup.	Do. . .		
c		Do. . .	Do. . .	Do. . .	40 per cent. syrup.	Do. . .	Sour, fair . .	May be used as a tart dessert fruit.
d		Do. . .	Do. . .	Do. . .	50 per cent. syrup.	Do. . .		
e		Do. . .	Do. . .	Do. . .	60 per cent. syrup.	Do. . .	Almost like preserves (*morabba*).	May be used as *morabba*, but moulds in a few days when opened.
2a	Sliced mature (sour)	May 16, 1923.	Do. . .	Do. . .	12·5 per cent. syrup.	Do. . .	Sour, flat taste . .	Only good for culinary purposes.
b		Do. . .	Do. . .	Do. . .	25 per cent. syrup.	Do. . .		
c		Do. . .	Do. . .	Do. . .	40 per cent. syrup.	Do. . .	Sour, good . .	May be used as a tart dessert fruit.
d		Do. . .	Do. . .	Do. . .	50 per cent. syrup.	Do. . .		
e		Do. . .	Do. . .	Do. . .	60 per cent. syrup.	Do. . .	Almost like preserves (*morabba*).	May be used as a *morabba*. It does not spoil so readily as (e) in No. 1.
3a	Sliced ripe but firm (slightly sour)	May 24, 1923.	Do. . .	None . .	12·5 per cent. syrup.	0-25 minutes .	Slightly sour, flat taste	May be used for culinary purposes.
b		Do. . .	Do. . .	Do. .	25 per cent. syrup.	Do. . .	Fair . . .	Suitable for a tart dessert fruit.
c		Do. . .	Do. . .	Do. . .	40 per cent. syrup.	Do. . .	Satisfactory .	Suitable for a sweet dessert fruit.
d		Do. . .	Do. . .	Do. . .	50 per cent. syrup.	Do. . .		
4a	Sliced ripe, soft and fibrous (sweet)	June 19, 1923	Do. .	Do. . .	12·5 per cent. syrup.	20-25 minutes .	Flat taste .	May be used for culinary purposes.
b		Do. .	Do. . .	Do. . .	25 per cent. syrup.	Do. . .	Fair	Too soft and fibrous for canning purpose.

c		Do.	Do.	Do.	40 per cent. syrup.	Do.	Good taste	Too soft and fibrous for canning purpose.
d		Do.	Do.	Do.	50 per cent. syrup.	Do.		
5a	Whole, ripe but firm (sweet)	Do.	Do.	Do.	12·5 per cent. syrup.	30-35 minutes	Flat taste	Good for culinary purposes.
b		Do.	Do.	Do.	25 per cent. syrup.	Do.	Do.	....
c		Do.	Do.	Do.	40 per cent. syrup.	Do.	Satisfactory	Good for a dessert fruit.
d		Do.	Do.	Do.	50 per cent. syrup.	Do.		
6a	Sliced ripe, soft and fibrous (sweet)	Do.	Do.	Do.	Mango juice	Do.	Flat taste	May be used for culinary purposes.
b		Do.	Do.	Do.	Mango juice + ¼ its own weight of sugar.	Do.	Fair	May be used for table purpose. (If the fruit is sweet it will not kee well in its own juice at less than 30 minutes boiling.)
c		Do.	Do.	Do.	Juice + ½ its own weight of sugar.	Do.	Good	
7a	Sliced ripe but firm (slightly sour)	June 14, 1923	Do.	Do.	Mango juice	Do.	Slightly sour, flat taste	May be used for culinary purposes.
b		Do.	Do.	Do.	Mango juice + ¼ its own weight of sugar.	Do	Good	May be used as a dessert fruit.
c		Do.	Do.	Do	Mango juice + ½ its own weight of sugar.	Do.		
8a	Sliced green (sour)	April 19, 1923	Do.	2 minutes	Water	25 minutes	Sour, flat taste	May be used for culinary purposes.
9a	Do.	May 17, 1923	Do.	Do.	2 per cent. brine	20 minutes	Sour, saline, flat taste	May be used for culinary purposes.
10a	Do.	May 16, 1923	..	None	Vinegar	Not sterilized	Pickled mango	Palatable product.
11a	Do.	Do.	..	Do.	Brandy	Do	Brandied green mango	Not palatable.
12a	Sliced ripe (slightly sour).	June 12, 1923	..	Do.	Do	Do	Brandied ripe mango	Palatable product.

In all the experiments the "cold pack" method was used, *i.e.*, the sliced fruits were packed cold in the containers which were filled up with hot syrup. Brine was also used hot, while vinegar, brandy and mango juice were used cold. As the green fruits are rather tough, they were blanched so as to soften their texture and remove the bitter astringent taste. The cut fruits oxidize very readily when exposed to the open air. For this reason they were always kept in water before use. Only sound fruits were selected for canning. All the jars and cans were scalded in hot water and marked on top with a file before they were sterilized. In order to insure efficiency in canning the different processes of peeling, packing, syruping, soldering, exhausting, tipping and sterilizing the containers should follow one after the other as quickly as possible.

In canning fruits sterilization can easily be done in an open vessel. Both green and ripe fruits can be sterilized successfully for 20 and 30 minutes respectively at 100°C. This depends on the nature of fruits as well as the size of the containers used. Generally glass jars take a little longer time for sterilization than tin cans when sterilized at 100°C. Moreover, quart jars require a longer period of sterilization than pint jars. The same rule applies to solder-top tin cans.

It may also be mentioned here that in sterilizing glass jars they were put in cold water and heated to boiling, while the tin cans were dipped in boiling water direct. In order to check over-cooking of the fruits the tin cans were dipped in cold water as soon as they were taken out of the sterilizer.

Summary.

1. The cold pack method of canning can best be adopted for home use and cottage industry purpose.

2. The fruits canned in sugar syrup give a better flavour, taste, appearance and keeping quality than in any other material.

3. Mangoes which are ripe but firm are best suited to canning. The mangoes should be picked carefully and only sound ones should be used for canning.

4. Ripe mangoes which are soft and fibrous become mashy when canned and so are not suitable for canning. They may be canned as concentrated juice.

5. Sour green mangoes can be canned for culinary purposes in water, brine or low percentages of sugar. Mangoes which are mature but not ripe will do well in canning as a tart dessert fruit.

6. Peeled mangoes, whether green or ripe, should be kept in water as soon as they are cut, otherwise they will oxidize very badly. Blanching of green mangoes softens their texture, removes the astringency and stops oxidation.

7. The percentage of syrup varies according to the acid content of the fruits canned. The higher the acidity, the more sugar is needed to make the produce palatable. Both the sugar and acid act as a preservative.

SELECTED ARTICLES

RECENT PROGRESS IN INDIA'S AGRICULTURE.*

The development of the industries of this country is a subject which has of late years given rise to much controversy. It has been discussed time and again in our legislatures as well as in the press. The conclusion generally arrived at has been that India has lagged behind the more advanced countries of the West in industrial development, and that it is therefore desirable to get a move on. Many new industries have been started with feverish haste; of these a few have prospered; of the rest some have failed entirely, while others are in a precarious condition financially. It is admittedly difficult, in these days of intensive competition, for such industries as enjoy no kind of monopoly, but which are required nevertheless to be run at a high standard of efficiency in order to make them profitable, to compete with similar industries in more advanced countries where labour and supervision are more skilled and conscientious. To counteract competition a small section of India's urban population demands protection for the industries in which they are interested; but protection is not an unalloyed blessing. It tends to raise the cost of commodities and to be disadvantageous therefore to industries other than those protected—agriculture for example. Agriculture is, and always will be, the premier industry of this country, providing, as it does, 3 out of every 4 of the inhabitants with a means of livelihood. Its development on scientific lines is the surest way of giving the great majority of the people of rural India the protection they require. Its development, moreover, offers unlimited possibilities of progress, for India's soils are fertile and her people are born husbandmen. But as the patient plodding tiller of the soil has not been able to visualize and state his needs with force and precision, the tendency is for his interests to be lost sight of when the subject of industrial development is discussed on political platforms. What he, as a producer, wants is free trade and facilities to buy and sell to the best advantage in the world's markets.

Government has done much for the advancement of agriculture since that great Viceroy the late Lord Curzon inaugurated his forward policy of agricultural development based on research, experiment, education and demonstration. In one short article it will be possible for me to refer only very briefly to the more important results which have within the last twenty years accrued from that policy. In that period varieties and strains of varieties of each important crop have been isolated

*Reprinted from The Indian Empire Supplement to *The Times of India Illustrated Weekly*, dated 2nd August 1925.

and tested with a view to getting types suitable for varying soil and climatic conditions. When difficulty in getting suitable types by selection has been experienced, new types have been evolved by cross-breeding. The success of this line of work has been phenomenal ; the improvement effected has appealed to the cultivator, as its adoption has not involved any material increase in his expenditure. The result has been that the area under improved varieties of crops has within the relatively short period of two decades increased from a few thousands to over 5 millions of acres. This line of work alone has given the cultivator an increased profit of at least 50 million rupees, or approximately 3½ million pounds sterling—a sum which covers the annual expenditure on the Imperial and Provincial Departments of Agriculture five times over. But there is no reason why this handsome profit should not be multiplied forty times, for there are still over 200 million acres being sown every year with inferior seed. Of the crops which have already been improved by seed selection and cross-breeding the most important only need be mentioned.

The improvement of wheat which is the main food crop of the people of Upper India, and which was grown in an area of over 31 million acres last year, has been carried out mainly on agricultural stations in the Indo-Gangetic plains of Northern India. The work done in evolving heavy yielding rust-resistant types of good milling and baking qualities, similar in class to Manitoba wheats, suitable both for internal consumption and export, is one of the finest achievements of the department. No variety of any other crop is so well-known in India to-day as the wheats commonly known as Pusa 4 and Pusa 12. These were evolved at the Imperial Agricultural Research Institute at Pusa, and are now being grown in an area of about 1½ million acres ; the area is gradually increasing not only in the United Provinces and the Punjab, but also in the Peshawar Valley, North Sind, Kathiawar, the Central Provinces, the Nilgiri Hills, the Southern Shan States and the Simla Hills. They have, too, made for themselves a home even in far distant Australia where they have at several agricultural shows carried off first prizes. In the Punjab, 8A and Punjab 11 are the two varieties which find most favour. In the United Provinces, the Pusa selections and Cawnpore 13 are widely grown. In the North-West Frontier Province, Pusa 4 has completely established its superiority over the local wheats. In every wheat-growing province the improved departmental wheats are slowly ousting local varieties.

The premier crop of India both as regards area and outturn is rice. On the average it occupies nearly 35 per cent. of the total cultivated area in India ; this amounted last year to over 78 million acres. In the rice-growing provinces different varieties have been isolated and tested under varying soil and climatic conditions ; the most promising varieties have been propagated on Government or on private seed farms, and large quantities of the improved seed given out to cultivators. The area sown last year with improved seed supplied by Agricultural Departments amounted to over 600,000 acres ; but this is only a part of the total area now cropped

with improved rices, for cultivators are themselves slowly propagating and distributing these improved paddies. The improved Indrasail, Kataktara and Dudshar paddies of Bengal, the Bhondu and Gurmatia selections of the Central Provinces and the Dahia of Bihar and Orissa are now household words in their respective rice tracts.

Another crop of great importance in India is cotton, the area under which rose to 23 million acres last year. Of late years the Indian crop has been extremely important in the world's markets owing to the fact that the yield of American cotton has been below normal. The export demand for Indian cotton has risen in consequence ; English spinners' takings rose from 67,000 bales in 1922 to 176,000 in 1923 and 257,000 bales in 1924. Much of this cotton was of superior staple. As the world's demand for this fibre is increasing faster than the supply, a period of high prices would appear to be inevitable. Of the Indian crop of about 5 million bales annually, Indian mills consume about 2 millions, leaving approximately 3 million bales for export. For export as well as for home consumption the demand for cotton of better staple is increasing, and Agricultural Departments and the Indian Central Cotton Committee are therefore co-operating in devising measures to enable the cultivator to grow cotton of a better class, and to take advantage of the increasing demand for the same. The area under improved varieties evolved by Agricultural Departments amounted last year to over $2\frac{1}{3}$ million acres, of which the greater part was sown with long staple cotton of the American type. In the Punjab the area under Punjab-American is now reported to be well over two-thirds of a million acres. The area under Cambodia—a somewhat similar type of exotic cotton grown in Madras—exceeded 200,000 acres last year. In Bombay and the Central Provinces, too, the area being sown with seed of improved varieties is rapidly increasing.

The Indian Central Cotton Committee has completed its third year as an advisory body, and its first since its incorporation with funds of its own under the Cotton Cess Act of 1923. It has continued to give much attention to the improvement of marketing, and to the checking of adulteration and other malpractices. The Cotton Transport Act has now been in force for over a year in those parts of the Bombay Presidency in which long staple cotton is grown. The unanimous opinion of the buyers is that the quality of the cottons now obtained in these areas has greatly improved in consequence, as shown by the enhanced prices paid for them. The Bill for the Regulation of Gins and Presses is also about to find a place on the statute book and will, it is hoped, prove a useful corollary to the Cotton Transport Act. The outstanding feature of the work of the Indian Central Cotton Committee, however, has been the progress made in getting its programme of research work on cotton started. The Institute of Plant Industry at Indore, the cost of which is being met partly by the Indian Central Cotton Committee and partly by the Central India States, was sanctioned in March 1924. The area of 300 acres of land provided by the Indore Durbar as a site for the Institute and farm has since been

taken over, and the necessary buildings are being erected. This Institute should in course of time become one of the leading cotton research stations in the Empire. The Indian Central Cotton Committee has also financed special research schemes in the various provinces, such as investigations on cotton wilt and cotton pests, the causes of boll and bud shedding, etc. They have, moreover, made grants to certain provinces to enable the Local Governments thereof to increase their staff for work on cotton, and provided a Botanist for the Punjab who will study the special problems connected with the introduction of long staple cottons of the American type now being grown under canal irrigation in that province.

The area under cane in India is about $2\frac{3}{4}$ million acres. The average yield of sugar obtained per acre ranges from 1·1 to 1·3 tons as against 3·5 to 4·5 tons for Java and 4 to 5 tons for Hawaii. The low yields obtained in India are partly due to the poor quality of the varieties of cane grown. The basal needs of sugarcane in this country are a source of combined nitrogen, adequate aeration and moisture. These needs are being carefully studied at several agricultural stations, but more especially at Pusa, at the Shahjahanpur farm in the United Provinces and at the Manjri farm in the Bombay Presidency. The aim in view generally is to increase the yield both of cane and *gur* (raw sugar) per unit area, to reduce the cost per ton of cane grown, and to devise more efficient methods of extracting the juice and of converting it into *gur*. The standard of crop production attained by European planters in Bihar and by the best cane-growers in Southern India already closely approximates to that of these farms. If it were possible to introduce this high standard in every cane-growing tract in India, the increased annual profits resulting therefrom would be colossal. But it is to the work being done at the Imperial Cane-breeding Station at Coimbatore that I refer in particular in this paragraph. The history of that work reads like a fairy tale. Twenty years ago it was supposed that sugarcane in India did not produce fertile seed and that there was little scope therefore for improving the crop by selection. Dr. Barber, a member of the Indian Agricultural Service, dispelled this idea by raising thousands of seedlings from cane seed at Coimbatore—a discovery which has enabled the department to breed a very large number of entirely new types : for when grown from seed the resultant plant shows wide variations in botanical, agricultural and chemical characters. The promising types evolved at Coimbatore are, after a preliminary test there, sent to Pusa and the provinces for further trial. Co.205, Co.210, Co.213 and Co.214 are four of the most promising kinds evolved up to date. In the Punjab and the United Provinces Co.205 is doing exceptionally well, while Co.210 and Co.213, after having been tested at Pusa, are now being grown on a large scale in North Bihar where they are giving from 50 to 100 per cent. more juice per unit area than the local varieties common to this tract. Their introduction, in fact, promises to revolutionize the whole sugar industry in this part of India, where white sugar is manufactured in large factories on a scale not equalled in any other part of India.

The world's supply of jute fibre is drawn almost entirely from North East India ; the monopoly is worth retaining. The area under the crop is necessarily regulated mainly by the demand from abroad and the price the raw material fetches in the market. The trade depression brought about by post-war conditions affected the area under this crop to such an extent that it shrank to 60 per cent. of the average area sown in the quinquennium immediately preceding the Great War. This resulted in a heavy reduction in output which naturally forced up the price and induced growers to increase the area under this fibre, with the result that it has again reached pre-war figures. Two main species of jute, namely, *Corchorus capsularis* and *C.*

Improved Fusa Tobacco, Type 28.

olitorius, are cultivated in India. One of the most successful pieces of work of the Bengal Agricultural Department is the isolation of superior yielding strains of both these species, and the distribution of seed of these strains to the cultivators. Departmental selections have found much favour more especially in Eastern Bengal ; it is estimated that at least half of the fibre imported into Narayanganj is the product of the seed originated from them.

In this short article it is only possible to refer briefly to the work being done on other important crops grown in India such as *juar*, linseed, tobacco, oil-seeds, fruit, potatoes, fodder crops, coconuts, tea, coffee, beans and pulses. In the case of most of these, varieties and types have been isolated and tested under varying soil and climatic conditions, with a view to propagating seed of the superior types for the use of the cultivator. The scope for further work in this direction is enormous ; it is no exaggeration to say that the yield obtained from most of the crops grown in this country could be doubled or even trebled by selecting heavy yielding types and by practising improved methods of cultivation.

Departments of Agriculture realize that the condition of the cattle in this country is one of the most essential factors affecting the development of agriculture. With the great increase in population which has taken place within the last 50 years the pressure on the land has also increased, and much land, previously available for grazing, has been brought under the plough. Large expanses of culturable waste which once supported breeding herds are now producing agricultural crops. If cattle are to be reared at a profit in arable areas, the husbandman must have a cow which will give sufficient milk and at the same time rear a good draught bullock. The muscular humped or zebu type to which Indian cattle belong has been developed mainly on draught lines, but the combination of the two qualities of milk and draught is found to some extent in such breeds as the Sahiwal, the Sindhi, and the Thar-Parkar to the improvement of which a great deal of time and attention is now being given on certain Government farms.

As regards the improvement of cattle generally, India is passing through a phase similar to that which prevailed in England about the middle of the eighteenth century but with this difference ; in England the improvement of cattle by selective breeding was initiated at that time by "gentlemen" farmers, while in India it is being done by Government. The foundation of distinct breeds is now being laid by Agricultural Departments ; and improvement is being effected in those breeds by selective breeding, crossing, better feeding and housing. In this way the milk yield of the herd of Sahiwal or Montgomery cows on the Pusa farm has been doubled within the last 15 years. Several of these cows have given over 6,000 lb. of milk in a lactation period ; while one of the cross-bred Ayrshire-Sahiwal cows in the herd has given 12,000 lb. which is about 12 times the yield ordinarily obtained from cows of draught breeds of this country. In years to come cattle-breeders will trace with pride the origin of their pedigree herds to the Pusa and other Government herds which are to be found in India to-day : for from these herds bulls of

good pedigree are already being supplied to cattle-owners for stud purposes. In this work of cattle improvement the Veterinary Department is rendering valuable assistance. The excellent results obtained by the Imperial Veterinary Research Institute at Muktesar in the immunization of herds against rinderpest by the simultaneous method of inoculation is worthy of special mention.

In India generally there are no pastures worthy of the name, and fodder crops as such are not commonly grown. In most parts of the country, moreover, many useless cattle are kept which get their share of the very limited supply of fodder available, to the detriment of those that are deserving of better treatment. Under these circumstances no great improvement can be effected by better breeding without first improving the food supply. Better feeding is as important as better breeding in short. On Government cattle-breeding farms new fodder crops such as berseem (Egyptian clover) are therefore being grown, and different methods of storing fodders tested. Accurate information regarding the digestibility and feeding value of different cattle foodstuffs is being collected, and facilities for a thorough training in animal husbandry and dairying provided by the opening of the Imperial Institute of Animal Husbandry and Dairying at Bangalore.

With a view to improving the milk supply in towns the Imperial Dairy Expert is giving valuable assistance in preparing dairy schemes suitable for urban centres, and the Imperial Dairy Farms at Bangalore and Wellington are being run as model farms of their kind. The Indians now being trained on these in the theory and technique of dairying will, it is hoped. start their own dairy farms in course of time. With a view to demonstrating the possibilities of sterilizing and transporting milk from rural areas where it is relatively cheap, to urban centres where it is dear, an up-to-date sterilizing plant has been set up on the Imperial Cattle Breeding and Dairy Farm at Karnal, and sterilized milk is now being sent from there to Calcutta—a distance of over 1,000 miles. Should this experiment prove a success, it will open up a vista of great possibilities for the dairy industry in India ; for milk costs about three times as much in our larger towns as it does in rural areas.

The work of the Engineering Sections of the Agricultural Departments in India is directed mainly towards developing and increasing the water-supply from wells by subartesian bores, and designing and testing agricultural implements. The introduction of improved tillage implements from the West has, undoubtedly, done much to raise the standard of farming in this country ; the efficiency of many of these implements is due to their having been designed by the trained engineers of certain firms working in collaboration with our agricultural experts. The pioneer work done in this direction has borne fruit, and thousands of improved implements are now to be seen in the countryside. The growth of the demand can well be gauged from the fact that one pioneer manufacturer in Bombay Presidency has a factory with a daily output of 200 iron ploughs which are all reported to be sold in the country. The number of improved ploughs sold by Agricultural Departments last year amounted to 20,227, of which just over 8,000 were sold in the Central

Provinces alone. In that province the sales in the course of 20 years have risen from approximately 25 to 8,000. These figures give one some idea of the demand which has arisen for improved cultivation—a demand which has resulted directly from the activities of the department. Of fodder cutters the number sold through departments last year was 5,473 : twenty years ago this useful fodder saving machine was being demonstrated to Indian cultivators for the first time. Of the value in rupees of the benefit accruing to the cultivator from the use of these and other implements and machines introduced it is impossible to form anything like an accurate estimate. Suffice it to say that by their introduction labour costs have been reduced and better crops obtained, and that the results already achieved show what enormous steps can be made towards raising the standard of farming in this country by a wide extension of the use of such implements.

To other lines of research and investigational work in hand I shall refer in the briefest terms. They deal with problems such as the conservation of soil moisture, the movement of nitrates in the soil, the reclamation of saline lands, the storage of farmyard manure, methods of producing artificial farmyard manure, the efficiency of different methods of green-manuring, the solubilization of mineral phosphates, animal nutrition, crop pests and diseases, the moisture requirement of crops, etc. Most of these investigations are still in progress and have not yet reached a stage at which the results can be of practical importance. They are, however, gradually adding to our knowledge of scientific agriculture, and without that knowledge it would be impossible to devise methods of improvement. The advancement of agriculture has, in short, to be based on knowledge which is the fruit of investigation and research.

In India, the Departments of Agriculture play many parts. Their research workers evolve and test improvements under a variety of conditions before recommending them ; this work is done mainly in laboratories and on experimental farms. The district workers of the department play an equally useful part in getting the cultivators to incorporate these improvements into their farm practice ; this necessitates the opening of Government seed and demonstration farms as well as private seed farms in the villages. It involves, too, the organization of agricultural associations, co-operative societies, agricultural shows, lectures, ploughing matches and the dissemination of information regarding improved methods of husbandry generally. In the more advanced provinces, the Department of Agriculture has become both an economic and an educative force of no small importance. It is, moreover, now working more closely than heretofore with the Co-operative Credit Department. At the last meeting of the Board of Agriculture held in January 1924, the progress made in non-credit co-operation and ways and means of stimulating further progress were discussed, and stress was laid on the paramount importance of the closest co-operation between the two sister departments. The expansion of non-credit agricultural co-operation with which Departments of Agriculture are mainly concerned will, it is hoped, proceed *pari passu* with the expansion

of credit societies, though the progress made by the former up-to-date has not been entirely satisfactory. Cattle-breeding, cattle-insurance and dairy societies in particular have generally failed to make any headway, owing, in nearly every case, to the members concerned not taking a live interest in them.

In the policy of agricultural development adopted by Government, education plays an important part. In addition to the two Imperial Institutes at Pusa and Bangalore which provide facilities for post-graduate courses in agriculture, agricultural chemistry, agricultural botany, entomology, soil bacteriology and mycology, we have six provincial agricultural colleges of which three are affiliated to Universities. The post-graduate courses given at Pusa and Bangalore are of a high standard, and qualify those who take them for the highest posts in the Indian Agricultural Service. In connection with the working of the Bangalore Institute, Government has also instituted an Indian Diploma in Dairying on the lines of the British National Diploma in Dairying, to be granted to students who have successfully completed a two years' course of instruction at this institute. Special agricultural schools of the middle school grade are under trial in some provinces, and short courses in special branches of agricultural practice are being given on Government farms. With a view to training young Indians in methods of research as applied to the improvement of cotton, the Indian Central Cotton Committee gives research scholarships annually to distinguished graduates of Indian Universities, and arranges for their training under experienced research workers in the Provincial Departments of Agriculture. These various facilities for agricultural education and research are proving a boon to the country in providing the department with qualified workers, in disseminating exact knowledge regarding better methods of farming and in encouraging men of the cultivating classes to qualify themselves in these improved methods. Every well run Government farm, and every effective piece of demonstration work carried out by the department has, moreover, its own educative value, and is paving the way for the advancement of agriculture. The pity is that these educative institutions cannot be multiplied a hundred fold. There are other possible methods of promoting scientific agriculture, for example the giving publicity through the printed word to the results obtained by research and experiment. That method, however, has its limitations in a country where illiteracy is the rule. Among the more important publications issued by the Imperial Department of Agriculture, are bulletins, memoirs, the Proceedings of the Board of Agriculture and the Agricultural Journal of India published bi-monthly. Provincial Departments publish bulletins and leaflets on subjects of local interest; some of them have their own agricultural journals in which articles describing the activities of the department are published from time to time.

Though the produce of the land in India exceeds in value all other sources of wealth put together, the farming industry has not yet attracted any considerable number of men of brains, enterprise and capital. The landowners whose duty it is to lead the way in the advancement of this great industry, live in towns mostly.

and take but little interest in the practical side of agriculture. Even in our legislative councils the elected representatives of the people have not yet fully realized the function of science in economic development, or the necessity of scientific and technical control over agricultural conditions and farming methods. This state of apathy admittedly does, and will continue to retard progress. There is little doubt, however, but that the various activities of Agricultural Departments are helping to break down this apathy, and to stimulate a real interest in improved methods. In some provinces, landowners are already playing their parts as leading agriculturists and have incorporated into their farm practice improvements recommended by the department. They have opened seed and cattle-breeding farms, and are helping in other ways to raise the standard of agriculture in their villages.

If properly staffed, the Department of Agriculture should in future make much more rapid progress than in the past in introducing improvements, for much spade work has already been done and the way paved for further advancement. Within 20 years, it should be possible to build up useful pedigree herds of the principal breeds of Indian cattle. Long before the close of that period there will be many hundreds of thousands of improved agricultural implements in India, and many millions of acres under improved varieties of our staple crops. But the rate of progress will depend mainly on the number and quality of the scientific investigators employed. With a mere handful of keen and capable men, the foundations of scientific agriculture have, in the short space of about 20 years, been wisely and effectively laid in this country. Future progress will depend on the thoroughness of the training given to Indians who are to build on these foundations. For that reason we attach the very greatest importance to the training provided at our agricultural colleges, at our Imperial Agricultural Research Institutes at Pusa and Bangalore, and at our Veterinary Research Institute at Muktesar. We look to these institutes to imbue young Indians with a spirit of research—the fountainhead of new knowledge on which the development of agriculture must needs be based.

THE UTILIZATION OF SEEDLINGS IN THE ESTIMATION OF SOIL NUTRIENTS.*

BY

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ANY one who has conducted manurial experiments in the field is well aware of the difficulties they present. Very often these experiments are interfered with by the weather, so that accurate results are only obtained if the researches are extended over several years. Pot-culture experiments are less dependent upon weather and have reached a high stage of perfection, but they require an extensive and special equipment which few institutions possess and could now only be purchased with difficulty owing to the high cost of material. Further, pot experiments are very long and troublesome and hence expensive : therefore, it is quite impossible for agriculturists to obtain by this means, and within reasonable time, any general information respecting the nutritive substances content of their cultivated soil. Hence there is urgent need of a method of mass experiment, by which any experiment station can carry out, without new, costly apparatus, hundreds and even thousands of soil sample analyses, to determine the nutritive substances present in them which can be assimilated by plants. Farmers should be given the opportunity of forwarding samples of their soil at all seasons, in summer as well as in winter, and these samples must be quickly, cheaply and accurately investigated, just as fertilizers and stock-feeds are tested. In this way, it will be possible, not only for the few favoured individuals who are in a position to conduct plant experiments, but also for the great mass of agriculturists, to suit the fertilizers applied to the requirements of their various soils and thus to farm systematically, a result that is of paramount importance, both from the point of view of national economy and the nation's food supply.

The principle upon which is based the carefully worked-out method (1) devised by myself and my colleague Dr. Wilh. Schneider (Bonn), is the hitherto unknown fact that young seedlings do not live as long as possible upon the reserve materials of the seed, but employ their rootlets, as soon as they are developed, to obtain nutritive substances from the soil.

If a large number of young seedlings are planted in a small quantity of soil, the starving rootlets extract all the assimilable nutritive substances their strength per-

* Reprinted from *Int. Review of Sc. and Practice of Agri.*, N. S., II, No. 4,

mits, but leave untouched the non-assimilable matter. In this manner, the plant rootlets separate out the soluble from the unsoluble substances, thus rendering a valuable service also to the chemist, since their choice is certain and leaves no room for doubt.

Our experiments were conducted as follows :--Upon the level bottom of some small glass dishes measuring about 100 sq. cm. at the base and 6 cm. high were spread 100 grm. of the soil to be tested, mixed with 50 grm. of pure quartz-sand, the so-called "glass-sand," which is free from any nutritive substances. Over this was laid 250 grm. of damp glass-sand, and upon the smooth surface were planted 100 seeds of the best, heavy seed-rye. The seedlings soon germinated ; they were carefully tended, and removed with their rootlets after 17 to 18 days and analysed. Only part of the mineral substances entering into the composition of the seedlings thus came from the soils to be tested, for a considerable amount was derived from the reserve stores of the seed. For this reason, we also carried out a blank experiment on barren sand to which no soil had been added and substracted the nutritive substances found from the total before obtained. The remainder was clearly derived from the soil.

So far, we have only used this method for the determination of potassium and of phosphoric acid, but we are convinced that it could also be employed in the case of other nutritive substances, such as nitrogen, for instance. The amount of potassium yielded up in this manner to young rye-seedlings by 100 grm. of soil, ranges, according to observations made, from 5 to 100 mg., while the phosphoric acid varies from 0 to 25 mg. Since 1 mg. per 100 grm. of soil is equivalent on an average to 30 kg. per hectare, the young seedlings on 1 hectare of soil abstract from the soil up to 3,000 kg. of potash and up to 750 kg. of phosphoric acid in 18 days. These amounts appear very large at first sight, but in reality they are very small. The seedlings used in the experiment were starving, which was necessary, otherwise, they would not have exhausted the soil, but plants under natural conditions take up a much larger amount of nutritive substances in the same short space of time. The reason that they do not exhaust the soil to an equal extent is simply that our cropping plants naturally have a thousand times as much soil at their disposal. Parallel determinations made according to the new method agree as exactly as chemical analyses, provided they have been executed by skilful and trained persons.

As can be seen from this brief description, the new method not only has the advantage of being quickly carried out by means of small packets of soil samples that can easily be forwarded by post, but it also has another point in its favour. Whereas in other vegetation experiments it is necessary to insure the optimum condition of the growth factors that are not involved in the test, and to supply an excess of all the nutritive substances not under consideration, in this new method all that is required is water and warmth. Especially good illumination is not even essential. In this manner the carrying out of the experiment is greatly simplified, there is no danger of producing unwelcome changes in the soil by the addition of other matters,

and it is thus possible to use the same material for the determination of the root-solubility of many nutritive substances instead of being necessary, as hitherto, to fit up the experiment anew for each fresh compound. In the usual type of vegetation experiment, the amount of nutritive substances contained by the soil is estimated from the yield of plant substance when the plants are gathered. Therefore the nutritive substances in question must not only have been taken up by the plants, but also turned to excellent account, which according to the "law of minimum" or as it is now called the "law of the influence of growth factors" is only possible when all the growth factors not involved in the test are at their optimum. By this method, however, there is no need to ascertain what the plants do with the nutritive substances they have absorbed from the soil; it is sufficient to ascertain the amount they have abstracted. Fortunately, the law of the influence of growth factors, which is so troublesome in other experiments, does not appear to affect the mere abstraction of nutritive soil substances by very young seedlings that still possess a large store of reserve material. We may imagine the plants saying, "let us diligently collect only stones for building and we shall soon find means of using them." In the open fields also, the first efforts of the germinating seed in early spring are directed to collecting building material to be used later, when the chlorophyll apparatus has become strong, under the influence of more intense irradiation.

From what has already been said, it is clear that a much larger number of tests can be made by the new method of vegetation experiments than was possible to carry out with the old systems; further, the experiments can be conducted at all seasons of the year. One important question, however, remains to be answered, *viz.*, is the new method accurate and trustworthy? That it is based upon existing laws has been shown by the agreement of parallel experiments and the great differences in the data obtained in the case of soils of unlike composition. How far this method is practically feasible must be decided by comparing the results obtained with those found by means of field manurial experiments, but as these are themselves affected by several sources of error, it is advisable to take the soil samples from experiment fields that have been long under observation. This has in fact been done, and I have always requested my colleagues when forwarding such samples, not to give me any information respecting the nature of the soil and its condition as regards fertilizers, until I have reported the findings of my experiments and made my calculations. They invariably complied with my wishes, with the results that will presently be given.

In order to determine by the seedling-method the nutritive substances required by a soil, it is needful to know how many mg. of each nutritive substance must be contained by an amount of the said soil, corresponding to 100 grm. of dry substance.

Judging from our present experience, we are of opinion that the *highest* yields can only be obtained from the plants in question (in the absence of potassic or phos-

phatic fertilizers), when it is possible for the seedlings to abstract, from a quantity of soil corresponding to 100 grm. dry substance, the following minimum amounts :—

	Potassium	Phosphoric acid
	mg	mg.
Rye, Wheat	14	8
Barley, Oats	18	7
Red clover	29	9
Lucerne	34	13
Meadow plants	38	10
Potatoes	37	10
Sugar-beets	39	12
Mangels	60	14

It is necessary to remark that these limits are based upon a general estimate and must be supported by the evidence of further experiment.

They apply to arable soil of the medium depth of 25 cm., where no nutritive substances have been added to the subsoil. It is of paramount importance that the amounts of nutritive substances supplied are enough to produce a maximum yield. Should it be impossible to obtain a maximum crop owing to the mechanical composition of the soil tested, or to the climate or lack of water, smaller quantities of nutritive substances that can be assimilated by plant roots will be sufficient. Therefore the data obtained from the seedling-method cannot be used as a general scheme. This objection applies not only to our method, but also to all other artificial systems. Field manurial experiments are indeed free from this limitation, but they have many other drawbacks.

The testing of our new method by the investigation of soil samples from experiment fields of known condition as regards fertilizers, included 65 potassium and phosphoric acid determinations. Most of the data are given in the above-mentioned treatise and as space is lacking here to reproduce the tables, it is only necessary to state that the agreement between the figures found and the condition of the fertilized fields, was in every case very satisfactory.

The following facts have not hitherto been published. The figures represent the amounts (in mg.) of potassium and phosphoric acid found by means of the seedling method in a quantity of soil corresponding to 100 grm. of dry substance. The experiments were conducted in the experiment field of the University of Halle

(Saale). This field had been planted with rye uninterruptedly since 1879; it was manured annually with stable manure and also with chemical fertilizers.

Kind of fertilizer	Potassium	Phosphoric acid
Unmanured	9·9	5·1
Nitrogen alone	7·2	3·5
8,000 kg. stable-manure	18·0	6·8
12,000 kg. stable-manure	22·2	8·3
Complete mineral fertilizer without nitrogen	35·0	15·0
Complete mineral fertilizer	30·6	16·7

The figures agree very closely with the actual conditions.

Experimental Field of Gottingen University.

The field had been planted with regular rotations of crops for 30 years and manured during that time as follows. No lack of potassium was noticeable (except, in the case of very exacting plants), even on the plots that had received no fertilizer.

Kind of fertilizer used	Potassium	Phosphoric acid
Unmanured	29·1	19·7
Nitrogen only	21·7	14·8
Phosphoric acid only	26·2	25·1
Potassium only	56·0	19·5
Complete fertilizer without potassium	25·5	17·4
Complete fertilizer without phosphoric acid	57·5	19·3
Complete fertilizer without nitrogen	61·9	22·0
Complete fertilizer	59·4	21·4

Here again the experimental results were a true reflection of the soil conditions as regards manuring.

Experiment Station of the Agricultural College ("Landwirtschaftliche Hochschule") of Bonn-Poppelsdorf, Bonn.

The experiments have been in progress since 1896. No lack of phosphoric acid has been shown even on the unfertilized plots. On the plots without potassium,

the yield was little decreased in the case of wheat, but was much lower than usual in some instances where the crops were of a more exacting character. The fertilizers were not heavily spread as in the case of the Gottingen experiments but the amounts given were calculated to replace, as far as possible, the substances abstracted by the crops.

Kind of fertilizer used	Potassium	Phosphoric acid
Complete fertilizer without nitrogen	24·5	15·8
Complete fertilizer without potassium	14·8	14·9
Complete fertilizer without phosphoric acid	25·6	9·0
Complete fertilizer	22·3	11·3

The figures found gave a very accurate conception of the condition of the field as regards fertilizers.

Soil composed of weathered Bunter-sandstone: field manurial experiment with winter-barley; previous crop five-year lucerne. The figures obtained were potassium 54·6 mg., phosphoric acid only 4·0 mg., therefore the soil must be regarded as very rich in potassium, but poor in phosphoric acid. The field manurial experiments gave the following results:

	kg. grain
Unmanured	2,950
Manured with nitrogen and potassium	3,090
Manured with nitrogen, potassium and phosphoric acid	4,720

Here again, the manurial condition as shown by the behaviour of the young seedling method was fully confirmed by the field manurial experiments.

The new method will be further extended with a view to the determination of the lowest values that will provide the amount of nutritive substances necessary to completely satisfy the requirements of different plants under various conditions of soil and climate, even in the case of a maximum yield. Whether rye is the best plant to use in these researches, will also be investigated, and whether it is sufficient to keep to a single variety of plant throughout the experiment.

The success already attained inspires us with the hope that this new method will be adopted in all agricultural experiment stations, as being a valuable aid to research, and useful in giving every farmer the opportunity of obtaining a clear idea of the store of nutritive substances present in his soils. It is hoped also that the scope of the new method will be further extended, for we believe it will prove of great service and enable us to penetrate quicker and deeper than heretofore into many of the domains of soil science and of plant physiology.

NOTES

IMPROVING THE VILLAGE FOWL OF INDIA.

FROM the experience of six years' work with poultry in this country and from experiments carried out in connection with the work of the U. P. Poultry Association, the writer is persuaded that if the village fowls were graded, that is to say, the ordinary village hens mated with males bred from good egg-laying strains, the result would well repay the undertaking. Grading in other branches of live-stock such as cattle and horse breeding has given satisfactory results, and for the peasant of India, whose economic conditions preclude the raising of pure bred stock, graded stock would bring in substantial profits in egg production.

A further reason for applying grading to the poultry of this country is the simplicity with which it could be done; the initial cost would be small and the rate of reproduction being so rapid, the benefits of increased food production would be rapidly realized.

In support of this contention, I would cite the recent experimental work done in this connection by Dr. Lippencott at the Kansas Experimental Station, U. S. A. In 1913, forty mongrel pullets were purchased of no particular value or breeding, and of any colour. These forty birds were divided into four lots and with each lot or pen of ten birds were placed the following cockerels :—

Pen 1 was mated to a White Orpington cock, whose dam laid 187 eggs in 10 months.

Pen 2 was mated to a Barred Plymouth Rock cock, whose dam laid 232 eggs in one year.

Pen 3 was mated to a White Leghorn cock, whose dam was bred from a pen of 232 egg layers.

Pen 4 was mated to a mongrel male with no record.

The following year 10 daughters of each pen were again mated to cockerels of the same breed as in the original matings. The following tables give the tabular results of egg records of each pen each year and of their respective descendants.

TABLE I.

Egg records of the females in Pen I and of their respective descendants in Pens V, IX, XIII (White Orpington grades).

Pen I. Ten mongrel pullets mated with White Orpington 1913-14	Pen V. White Orpington grades mated with W. O. cockerel 1914-15	Pen IX. White Orpington grades mated with W. O. cock 1915-16	Pen XIII. White Orpington grades 1916-17.
Total egg production 848	Total egg production 1,268.	Total egg production 1,058.	Total egg production 796.
Average egg production 84·8.	Average egg production 126·8.	Average egg production 105·8.	Average egg production 79·6.

TABLE II.

Egg records of the females in Pen II and of their respective descendants (Barred Plymouth Rock grades).

Pen II. Ten mongrels mated with Barred Plymouth Rock cockerel 1913-14	Pen VI. Barred Plymouth Rock grades mated with B. P cockerel 1914-15	Pen X. B. P. Rock grades mated with B. P. R. cockerel 1915-16	Pen XIV. Barred Rock grades 1916-17
Total egg production 985.	Total egg production 1,325.	Total egg production 1,496.	Total egg production 1,556.
Average egg production 98·5.	Average egg production 132·5.	Average egg production 149·6.	Average egg production 155·6.

TABLE III.

Egg records of the females of Pen III and of their respective descendants (White Leghorns).

Pen III. 10 mongrels mated with White Leghorn cockerel 1913-14	Pen VII. W. L. grades mated with W. L. cock 1914-15	Pen XI. W. L. grades mated with W. L. cock 1915-16	Pen XI. White Leghorn grades 1916-17
Total egg production 723.	Total egg production 1,559.	Total egg production 1,886.	Total egg production 1,926.
Average egg production 72·3.	Average egg production 155·9.	Average egg production 188·6.	Average egg production 192·6.

TABLE IV.

Egg records of the females of Pen IV and of their respective descendants (mongrels).

Pen IV. 10 mongrels mated with a mongrel cock 1913-14	Pen VIII. Mongrels mated with mongrel cock 1914-15	Pen XII. Mongrels mated with mongrel cock 1915-16	Pen XVI. Mongrels 1916-17
Total egg production 958.	Total egg production 1,040.	Total egg production 1,452.	Total egg production 1,296.
Average egg production 95·8.	Average egg production 104·0.	Average egg production 145·2.	Average egg production 129·6.

TABLE V.

Average per cent. of increase or decrease in first year of production of each generation of offspring compared with the original mongrel pen.

Breeds	First generation	Second generation	Third generation
White Leghorn grades	115·62	160·85	166·39
Barred Plymouth Rock grades . . .	34·51	51·87	57·97
White Orpington grades	49·52	24·76	6·13
Mongrels	8·55	51·56	35·28

From the results it will be seen that there was a very marked improvement in all three groups of graded birds in comparison with their mongrel mothers in the first generation. In the second generation the improvement continued especially in the Leghorn grades, but the Orpington grades did not lay as well as their mothers. In the third generation the improvement continued for Leghorn and Rock grades though at a considerably reduced ratio. One fact comes out strongly that the egg production of the original mongrels gave no basis for predicting the probable production of their descendants ; the fact suggests, rather, that the production of the descendants was largely determined by the sires used.

The conclusions of the test among others were :—"That the egg production of a poor producing mongrel flock of chickens may be quickly and markedly improved by grading through the use of cockerels from high laying families."

From personal experience in the United Provinces, a *desi* hen mated to a Brown Leghorn cockerel produced a daughter that laid 61 eggs in 66 days. This bird was trapnested by me at the Lucknow Model Poultry Farm. The varieties of Leghorns bred from high producing males have in our experience in the United Provinces given best results and suit the country hen best in type and size.

From experimental matings of Rhode Island Red cocks with White Chittagongs we have produced pullets showing at birth sex-linked inheritance, *i.e.*, all pullets being red and cockerels white and laying 50 per cent. larger sized eggs and showing better egg records than their Chittagong mothers. Many other examples can be quoted.

There are now in India many cockerels going to waste that with a small amount of organization and expenditure could be bred with village stocks under supervision, and we would suggest that wherever possible this should be done at all agricultural farms where interest in poultry is taken and the experimental work should be tested in villages in close proximity to such farms.

I am hoping to put up before Government a scheme for the manufacture in India of egg powder for export abroad. This industry is largely carried out at present in China. If adopted in India, it would create a peasant industry, and as there would be an increased demand for eggs to supply to the factories the grading of the village fowls would mean a very much larger revenue to the country. Unless we do something definite and practical of this kind we are wasting good opportunities of benefiting the people among whom we work. The hardy country hen would well repay for grading, and the means of doing so are well within our reach. [MRS. A. K. FAWKES.]

THE ROMANCE OF THE PLOUGH.

THE plough is one of the romantic things of the world. It has appeared in all ages, among all peoples, and its conception is apparently one of the natural instincts of mankind. Its history goes back to the Egyptians, and the early Biblical writers were familiar with its use. The Romans, in their long occupation of four centuries, brought ploughs to Britain, and it is said that they used the wheel and the removal breast, but they found ploughs in Britain when they came. It may be said with confidence that all primitive ploughs were made of wood. The early Greeks used the trunk of a small tree, with two opposite branches, one forming the share or point, the other the handle, while the trunk formed the beam. It is recorded that iron—that is, wrought iron—ploughshares or points were used many centuries before the Christian era by the Romans and the Persians.

In those troublesome times it was ploughing one year and fighting the next, and the plough points would be hurriedly beaten into swords and spears and back again when the war was over. One strange thing about the plough was the idea in many centuries that iron passing through the soil—especially in the case of the breast—poisoned it, and an American paper stated that this belief was not entirely confined to the Ancients, as the same superstition was shown by many American farmers when the first iron ploughs were originally introduced in America about 1797. It may be mentioned that wood is in one respect a very good material for a

plough breast, as in sticky soils it clears itself much better than an ordinary iron breast. Glass and porcelain breasts have also been experimented with, having the same object of view. In modern days, steel breasts, made under a special and expensive process, with a very hard and highly polished surface, give perfect results in the most adhesive soils. Before their introduction the ploughman working under sticky conditions had to carry a "spud," wherewith to constantly remove the accumulation from the breast. Two interesting points in connection with ploughing may be mentioned here. In the Cottonian manuscripts there is shown a picture of a Saxon ploughing, in which the ploughman is carrying an axe wherewith to break the clods from time to time as he goes along. In 1634, an Act of Parliament had to be passed to stop the barbarous custom then prevalent in Ireland of fastening ploughing horses by the tail.

Plough shares were made of only wrought iron up to 1785, when a patent was granted to Robert Ransome—the founder of the now famous Ipswich firm of Ransomes, Sims & Jefferies Ltd.—for a process of making and tempering cast-iron ploughshares. In 1803 a further patent was granted to Mr. Ransome for a process by which the undersurface of the share was chilled, becoming extremely hard, while the upper part remained soft and tough, and wearing away more quickly than the lower part, left the edge always sharp. In 1808 Mr. Ransome patented the great feature of all modern ploughs, *viz.*, the construction of the bodies in such a way as to admit of their being easily taken to pieces on the field, and fresh parts substituted. Many other able men combined to improve the construction of the plough in Great Britain. Among others may be mentioned Small, Foljambe, Tasker, Ball, Howard, Hornsby, Page, Cooke, Gray, Wilkie and Sellars. The result is the improved plough of to-day, which exists in many forms to suit all kinds of soil and conditions of work.

The evolution of the plough may be summarized as follows: (1) A pointed piece of wood dragged through the ground; (2) the same with wrought-iron protection; (3) the same with a point of entirely wrought-iron; (4) wrought iron point or share working with a wooden breast; (5) as (4), but with wooden breast covered with wrought iron plate; (6) (end of 18th century) share and breast sometimes wrought iron, covered with wrought iron plate; (7) about 1803, breast with cast-iron or steel breast, sometimes chilled; (8) (present day) breasts of all materials, including iron, chilled iron, and steel of various qualities, shares of steel, chilled iron, or other special material. It will thus be seen that this universal cultivating implement of the human race—the plough—was first fashioned from the branch of a tree by the rough axe of the earliest cultivators of the soil; then by the rude carpenter of early times; after that to come into the hands of the village blacksmith, and finally to be manufactured by the trained engineer, assisted by all the modern appliances and scientific resources of civilization.

British engineers were once again pioneers, and so far as the modern plough is concerned, their products soon became famous throughout the world. The emi-

grants to British Colonies in the '40's and '50's took British ploughs with them. They were also sent to the United States and India. The object of the plough is to turn over the soil and expose a new surface to the atmosphere. The winter's frosts disintegrate the clods, while from exposure to the air the soil gathers fresh vitality. There are many forms of furrow to suit different soils and conditions for which many different shapes of breasts and shares are designed. Further, the ploughs of to-day are of many different kinds. Ploughs for subsoiling, ploughs for ridging, ploughs for draining, ploughs for laying the furrow all one way, and ploughs for direct traction either by steam or petrol and paraffin tractors. The object of subsoiling is while leaving the fertile land on the top to break or stir up the subsoil to enable deep-rooted crops to penetrate the hard surface of the previously undisturbed soil. In a recent experiment in the neighbourhood of Ipswich with sugar beet, a wide strip across the middle of a field where this was to be planted was first subsoiled. In due time it was found that the subsoil portion produced beet of better shape and larger size than came from the part of the field not so treated, which repaid many times the extra expense incurred. Ploughs for laying the furrow all one way are made in many different forms. They are valuable for ploughing on hill sides, and on light land where the open or water furrows of the ordinary ploughing are not necessary.

The double plough in its simplest form was in use so long ago as the reign of Cromwell, but it was heavy, clumsy, and unwieldy, and it was not until the Jefferies patent lifting apparatus was introduced in 1870 that double and multiple ploughs became a really practical proposition. By the use of this apparatus, not only can the depth of the ploughing be regulated with great ease, but it is also invaluable for lifting the plough out of work at the end of the furrow, and for transit from place to place.

Since the introduction of the petrol and paraffin tractor, the tractor plough has reached a very high development. Ploughs of this type are generally fitted with a self-lifting arrangement. To lift the ploughs out of the work, the driver of the tractor simply pulls a string attached to the self-lift apparatus off the plough, and the same pull of the string lets it into work again. Another interesting form of plough is the so-called "stump-jump plough," which has a considerable vogue in the Colonies. It is so constructed that when meeting a buried rock or tree stump, it automatically climbs over the obstacle and enters into work again without damage to the plough. A modern and important development of the plough is the "disc plough," which has proved itself especially efficient in ploughing land baked hard by the sun. This type of plough is largely used in South, East and North Africa, and is coming into its own in India and other hot countries. This article has dealt only with ploughs for animal draft and for direct traction. Great service has also been rendered to the agricultural industry by the double engine or cable system of steam ploughing, but we cannot now enter further into the subject. [*Burn's Engineerinj Magazine*, April, 1925.]

SYNTHETIC FARMYARD MANURE.

THROUGH the courtesy of Mr. E. Hannaford Richards, B.Sc., F.I.C., Managing Director of the Agricultural Developments Company, we are able to publish further details of the Adco process, and to make certain amendments to former articles which have appeared in this Journal (*Tropical Agriculture,* Vol I, No. 8, August, and No. 9, September 1924, pp. 116 and 133).

At the outset, it is necessary to state that the proprietors of the Adco process now desire to describe their product as *synthetic* rather than artificial manure, since this term has given the erroneous impression that the material is of an inorganic or chemical nature, whereas actually it comprises very nearly the same components as farmyard manure (in particular the valuable organic matter), with the difference that its ingredients have been synthesized or built up from the same main raw material as farmyard manure by the agency of added bacterial stimulants, but without the intervention of farm animals.

As a result of recent investigations, it has been demonstrated that the decomposition of plant residues, through the activity of micro-organisms, takes place in several stages. First of all, sugars, pentosans and starches are consumed by a variety of organisms, notably fungi. It seems likely that these carbohydrates are built up into living cell material (protein), which is itself broken down at a later stage, providing the most available type of organic matter in the finished manure. Cellulose itself decays comparatively slowly, and may be regarded as a "scaffold" supporting and distributing the decomposition products of the other simpler carbohydrates. Contrary to former opinion, it has also now been proved that reducing sugars in moderate amount, and higher nitrogen compounds (if not bactericidal), actually assist rather than hinder the formation of a satisfactory manure.

In common with all living plants, the micro-organisms concerned in cellulosic fermentation, require nitrogen for their sustenance. Frequently, the amount of nitrogen contained in the raw material upon which they act, is insufficient for their needs. Consequently, it is necessary to add nitrogenous compounds to augment the supply naturally present, if a satisfactory fermentation is to be obtained. In the case of cereal straw usually 0·7 per cent. of nitrogen, measured on the dry weight of the straw, is required to make up this deficit. For cane trash, the necessary amount is probably nearly the same. The additional nitrogen may be supplied in the form of some inorganic nitrogenous compound (Adco process), or as urea contained in the urine of farm animals (Mauritian method, as well as the ordinary farmyard or pen manure process).

In their earliest experiments, the Rothamsted investigators used ammonium carbonate as a source of nitrogen, but for reasons of cost, sulphate of ammonia was employed in later large scale trials. This gave fairly good results, but its sulphuric acid content was objectionable, while the high solubility of the salt led to accidental loss in distribution. Mr. Richards states that for two years past the Adco Company has manufactured its own reagent which contains no sulphate of ammonia. The

new reagent ensures a neutral or slightly alkaline fermentation, while the phosphate nitrogen ratio in the finished manure is greatly improved. The formula of the reagent has not yet been divulged.

The extent to which fixation of *atmospheric nitrogen* may proceed during the manufacture of synthetic manure, through the agency of specific micro-organisms, has apparently been unduly exaggerated. Mr. Richards' laboratory experiments commenced in 1915, and repeated with the co-operation of Dr. Hutchinson in 1918-19, have conclusively shown that, even under the most ideal conditions, the actual gain due to the fixation of atmospheric nitrogen seldom exceeds 0·5 per cent. of the dry weight of the straw employed as raw material. Usually it is much less. In large scale trials with straw heaps, the maximum gain was found to be only 0·1 per cent. Thus little additional advantage can be expected from the co-operation of atmospheric nitrogen fixers.

In the manufacture of synthetic manure by the Mauritian method, the writer found that the increase in nitrogen over that contained in ordinary Trinidadian pen manure, was only about 0·036 per cent. of the weight of the final manure, or about 0·156 per cent. of its dry weight, which amply agrees with Mr. Richards' experience.

The fact that the increase in nitrogen due to atmospheric nitrogen fixers is relatively small, is explained on the grounds that there is usually only a limited amount of suitable carbohydrate (sugar, pentosan, starch) available for the nourishment of the micro-organisms that can assimilate either atmospheric nitrogen or chemically, combined nitrogen, and that, when this supply has been exhausted, no further assimilation can occur. Consequently fermentation then proceeds very slowly.

On the other hand, if the supply of suitable simple carbohydrate in the raw material is considerable, but at the same time, the amount of nitrogen present in the manure is insufficient, the nitrogen assimilating micro-organisms may draw on the reserves of nitrate nitrogen *in the soil*, and the manure may then exert a depressing effect on crop yield when first applied to the land. Herein lies the danger of employing too much cellulostic litter in the manufacture of ordinary farmyard manure, and indeed of Mauritian pen manure also.

For obvious reasons, it is not easy to arrange the proper balance of nitrogen to carbohydrate when manure is made by treading litter under stock. On the other hand, once the normal composition of the raw material has been determined, the Adco process enables a well-balanced manure to be produced without any risk of those losses of valuable fertilizing constituents which are generally recognized as inevitable under the older systems.

This, then, is the secret of the Adco process. By means of a long series of laboratory experiments augmented by numerous large-scale trials, the Rothamsted workers have gradually evolved a formula and a mode of operation which yield results that are highly satisfactory in respect to the manurial quality of the final product. It only remains to be seen whether or no the use of Adco synthetic manure compares favourably with other systems of manuring when considered in economic

aspect. Various trials are being made, not only in Great Britain, but in many tropical and subtropical countries as well, in order to settle this question, and it may interest our readers to learn that large-scale trials will probably soon be inaugurated in Trinidad under the joint auspices of the Trinidad Department of Agriculture and the Imperial College of Tropical Agriculture. The results of these trials, when available, will be published in this Journal. [F. HARDY in *Trop. Agri.*, II, No. 5].

SUGARCANE TRASH AS MANURE.

IN the last number of this Journal,[1] an authoritative account of recent advances in our knowledge concerning the natural decomposition of cellulosic plant material was presented. It was stated that the investigations of the Rothamsted workers have demonstrated that the micro-organisms responsible for the break-down of straw, cane trash, and any similar vegetable matter that may be applied to the land, require for their sustenance a certain amount of nitrogen. The initial nitrogen content of straw and the like is usually not sufficient to supply this need, nor can much aid be expected from atmospheric nitrogen-fixing bacteria which generally accompany the cellulose organisms. Consequently, nitrogenous substance in the form of urea in urine, or in the form of some other suitable compound, such as that which comprises the main ingredient of "Adco" mixture, must be added before a satisfactory cellulosic fermentation can be obtained. If such initial addition be omitted, the micro-organisms *may draw on the nitrogen reserves of the soil* and this may lead to seriously diminished yields, because the micro-organisms will compete with the crop for nitrate.

There has sprung up amongst sugarcane planters in some countries a certain disregard of the possible losses that may be incurred by the practice of burning trash off the canes before reaping. In many instances, it has been urged that cane fires are really beneficial, in that they made reaping a much more rapid, cheap, and easy operation (doubtless justifiable in the case of certain sugarcane varieties, such as Uba), and in that they effect partial sterilization of the surface soil, and serve an even more useful purpose in destroying the spores of fungi and the eggs of injurious insects. Whilst these desirable effects are no doubt frequently attained by trash burning, they should be offset against loss of sucrose in the burnt canes, and destruction of humus in the soil.

An additional reason sometimes put forward in defence of trash burning, is that the extra trouble and expense involved in the stripping and ploughing-in of bulky cane trash apparently is not always repaid by increased crop returns, such as might reasonably be anticipated. As far as the writer is aware, no conclusive experiments based on actual costing have ever been conducted to test this supposition, but it

Tropical Agriculture, II, 5.

appears likely that, in certain instances, the addition of a large bulk of cane trash to a soil initially poor in nitrogen reserves, might temporarily deplete the soil of nitrate (for reasons already given), and thus reduce the magnitude of the crop.

In support of this opinion, it might be stated that cereal growers in northern countries have found that the practice of ploughing-in fresh straw generally results in a marked depression in the yield of the succeeding crop. In order to overcome this difficulty, the Rothamsted investigators[1] have suggested that a leguminous crop should be grown immediately following an application of undecomposed straw. The leguminous crop would, of course, be largely independent of a soil-nitrate supply because of the activity of its nodule bacteria, and, moreover, its residues would furnish nitrogen in amount amply sufficient to supply the needs of straw-decomposing organisms. A beginning was made at Rothamsted by investigating the action of straw chaff upon the development of root nodules of soya beans growing in pot cultures of soil. A large increase in the number of root nodules was found to occur as a result of the straw addition. In one instance, the number increased from 234 to 636. Nevertheless, the yield of the leguminous crop was not correspondingly increased, because, whilst the straw stimulated the infection of the roots with nodule organisms, it did not cause an increase in root growth, so that the root systems were too small adequately to feed the increased number of nodules. Subsequently, the combined action of straw and phosphate was tested. It is well-known that phosphates stimulate root development, and it was thought that its effect might therefore give, in addition to a greater number of nodules, a considerable increase in crop. These expectations were completely realized in preliminary trials, and it is expected that eventually a new system of manuring will be evolved, by which unrotted straw may be applied to soil, followed by a leguminous crop manured with phosphate, so that the nitrogen losses usually attendant upon the incorporation of cellulosic material into soil may be overcome.

Sugarcane planters might with advantage note the results of this important work at Rothamsted, for it is gradually being realized, at least in tropical countries that have long been growing the sugarcane crop, that some sort of rotation must be practised, and greater care taken to conserve or to build up the supply of organic matter in the soil, if serious deterioration in fertility is to be avoided.[2] [F. HARDY in *Trop. Agri.*, II, 6.]

TRANSMISSION OF A ROSETTE DISEASE OF THE GROUNDNUT.

The important part played by insects in the dissemination of the virus diseases of plants is now recognized, and experimental proof of transmission by particular

[1] Discussion on the action of Bacteria on Cellulosic Materials. *Jour. Soc. Chem. Indus.*, 1923, XLII, 26, remarks by H. G. Thornton, p. 286 T.

[2] Report of a Committee on Agricultural Progress, American Sugar-cane League 1923 (Louisiana) in *Facts about Sugar*, July 14, 1923, p. 34. Also S. F. Norse, *ibid*, Aug. 11, 1923, p. 131.

insects exists in a number of cases. As a result of investigations during the past season, we are able to add one more to the list of those diseases of which the insect vectors are known.

During recent years the cultivation of the groundnut or peanut (*Arachis hypogea*, L.) in parts of South Africa has been seriously handicapped by outbreaks of a disease locally known as "rosette." The leaves of an affected plant are small, twisted and closely crowded, owing to the non-elongation of the internodes of the stem, giving the plant a bunched or rosetted appearance. These leaves are generally yellow, but in many cases show definite mottling. No seed is set by a plant diseased at an early stage of growth; and the yield is materially reduced by late infection.

We believe this rosette disease to be identical with the East African "krauselkrankheit" of Zimmermann (*Der Pflanzer*, 1907 and 1913), with the Javan "krulziekte" of Rutgers (*Dept. Landbouw. Nijv. en Handel in Nederl. Indie, Meded. v/h Instituut voor Plantenziekten*, 1913) and with the "bunching" or "clumping" recorded from West Africa and India.

All investigators of this disease failed to attribute it to any parasitic organism, or in fact to any definite cause, and its nature remained little understood. Zimmermann (1907) directed attention to a similarity between this disease and tobacco mosaic; more recently, the comparison was rendered the more obvious by extensions in our knowledge of the plant virus diseases, so that pathologists generally assumed that the peanut rosette disease belonged to the virus group. Support to this view is now afforded by experimental transfer of the disease. Work carried out under our direction at Pretoria and independently at Durban has demonstrated the ability of *Aphis leguminosae*, Theo., to transmit the disease. In these experiments aphids, removed from rosetted peanut plants, were allowed to feed upon a single mature leaf of a healthy plant, suitably protected from the feeding of any other insects. The characteristic rosette symptoms appeared afterwards in the young leaves of a large proportion of these plants. Control plants, receiving identical treatment but protected from the feeding of any insects, remained healthy.

During the course of this work, collections were made of all the suctorial insects occurring upon diseased peanuts in the field. Tests of more than two hundred individual jassids and fulgorids belonging to at least eight species afforded no single infection of the experimental plants. [H. H. Storey and A. M. Bottomley in *Nature*, No. 2907.]

THE SURVIVAL OF PINK BOLL WORM LARVAE IN BURIED SEED DURING THE WINTER IN EGYPT.

The following is a summary of a paper on the subject by C. B. Williams and Ibrahim Eff. Bishara, published as Bulletin No. 58 of the Ministry of Agriculture, Egypt, Technical and Scientific Service :—

The results obtained confirm entirely those reported by Willcocks, namely, that —

(1) The death rate of larvæ buried in the ground in winter is least near the surface and greatest at greater depths. At 30 centimetres there is no survival.

(2) The moister the land is kept during the winter the more rapid the death rate of the larvæ.

The larvæ die very rapidly in berseem and few if any reach the following crop. In wheat they survive a little longer and in dry fallow a number live till the next crop.

Excessive artificial watering, such as watering the land every two weeks, as in 1922-1923, or a very heavy continual watering for a short period at the commencement as in 1923-24, increases the death rate to a still greater extent and no moths reach the following crop under these conditions.

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary, Indian Central Cotton Committee, has sent the following abstracts for publication :—

COTTON CULTIVATION IN TURKEY.

THE cotton-growing districts of Turkey may be divided into three groups : Adana in the extreme south-east of Asia Minor, Smyrna in the west of Asia Minor and the Valley of Sakaria. Of these, Adana is the most important centre and an average crop of over 100,000 bales is obtained. The present cotton-growing area of the Adana district is known as the Cicilian plain ; it is bounded by three large rivers and lies between the Taurus Mts. and the Sea. It comprises rich alluvial lands to the extent of 4-5 million acres which are eminently suitable for cotton production. Lands adjoining the Cicilian plain are also suitable. Improved methods of cultivation are receiving the attention of the authorities, the agricultural school in Adana is being improved and the first trials of improved seeds and artificial manures are to be made this year. The native cotton, the peculiarity of which is that its bolls do not open and that they all mature at the same time, is $\frac{7}{8}$ inch in staple and white in colour. The American type averages 1-1$\frac{1}{8}$ inch staple and is very silky. The valley of Sakaria provides the best quality of native cotton obtained from Turkey ; the staple is 1-1 $\frac{1}{16}$ inch, very silky and extremely white. [*Text. Rec.*, 1925, **42**, No. 504, 50-51.]

COTTON SELECTION IN UNITED STATES OF AMERICA.

IN judging which variety is most suitable for a particular locality, the following considerations should be taken into account. Outturn at the gin is not neces-

sarily a true measure of yield per acre ; and high outturn, as in the case of Half and Half, is usually associated with such inferiority of staple that it sells only at a large discount. Short staple varieties are not necessarily more productive than longer staples. Several very early and prolific varieties are known, which very often outyield short staple varieties. Among these are Acala, $1\frac{1}{8}$ to $1\frac{3}{16}$ inch ; Lone Star $1\frac{5}{16}$ to $1\frac{1}{8}$; and Columbia and Durango $1\frac{3}{16}$ to $1\frac{1}{4}$ inch. Some varieties are undesirable because they lack uniformity. Under boll-weevil conditions earliness and productiveness are important characters. There are, however, mistaken ideas of earliness, and in former years inferior, small-bolled varieties were grown on account of them. An early variety is rightly one that rapidly sets and matures a crop. This is not necessarily the same as the very early appearance of the first flowers or first open bolls. Some big-bolled varieties yield equally well. Very short-jointed or cluster varieties are more liable to excessive shedding and are difficult to pick. Long-jointed open-type kinds are late in maturing and poor yielders. Cultural operations are easier where plants stand erect, and spreading or prostrate varieties should be avoided. Varieties having a strong central stalk with short fruiting branches and many of them, produce more flowers in a given time than varieties having long fruiting branches. The bolls on the former are set more rapidly, they are held from the ground and sustain less weather damage, and in consequence they are easier to pick. Staples longer than $1\frac{1}{8}$ to $1\frac{3}{16}$ inches are subject to extremely variable demand. In balancing the yield obtainable per acre for the different available varieties, the average prices for the different staples over at least 5 years should also be taken into consideration. [*U. S. Dept. Agri. Farmers' Bull.* 1384, pp. 15-17. O. F. Cook and R. D. Martin.]

Cultivation of Acala Cotton in United States of America.

Acala, a relatively newly acclimatized Mexican type, is very early and prolific. When long staples are in demand it gets a distinct premium over ordinary American, yet it is not long enough to be excluded from the short staple market. Several communities are specializing in Acala and developing supplies of seed. One is located in the Coachella Valley and others are found in N. Texas and Oklahoma. [*U. S. Dept. Agri. Farmers' Bull.* 1384, p. 16. O. F. Cook and R. D. Martin.]

Delinting and Recleaning of Cotton Seed.

Uniform and rapid germination of the seed is an important factor in cotton production, and to this end delinting and recleaning are strongly advocated. Tests on the Express variety show that the seed may be almost completely stripped of its fuzz with not over 1 per cent. saw cut injury ; actually 161 lb. linters per ton was removed and the damaged seed amounted to only 0·8 per cent. Two days were gained, under ideal conditions of moisture and temperature, in germination

by this process. The viability of the seed does not appear to be affected. Delinting, however, while removing much of the trash as well as the fuzz, leaves an uneven sample in respect of the weight of the individual seeds. Recleaning machines are devised to remove trash, loose lint, dirt and very small and broken seeds by screening, and light-weight seeds by blowing. This operation is not performed effectively unless the seed has been previously delinted. From ordinary ginned seed many good seeds are rejected and some light-weight seeds are retained, owing to the interference of the fuzz. These two operations are therefore complementary. Of the treated seed less need be sown per acre, so that the cost to the farmer is no greater than for ordinary seed straight from the gin. The cultural advantages are very great. The smooth seeds separate easily and are more evenly distributed in the rows by the planter. Even germination assures the breaking of the soil crust and a more uniform stand. Where the close spacing system is in vogue the evenness of planting is especially advantageous. [*U. S. Dept. Agri. Dept. Bull.* 1219. J. E. BARR.]

SUPPLY OF COTTON SEED IN U. S. A.

Approximately 500,000 tons of seed are needed annually in planting the cotton acreage in the United States. Of this quantity only 30 per cent. is supplied through commercial channels and the remainder is raised by the farmers themselves for their own succeeding crops. Much of the commercial seed is of the ordinary gin-run quality and is often no better than that obtainable from the local public gin. A very high percentage of the land is therefore sown with seed from impure and frequently unnecessarily inferior stocks, and, with the resulting general lack of uniformity in the produce, this is responsible for much industrial and economic waste. The remedy lies in the general adoption of the one variety community cotton system, whereby each locality, instead of the individual farm, becomes the unit of varietal production. This system requires : (1) The consent of all farmers in the locality to the growing of one particular strain. (2) The isolation of seed increase fields from other cotton fields, and the adoption of rigid precautions in preventing the mixture of seed during ginning operations. (3) The maintenance of purity and uniformity by persistent selection, roguing and local breeding. (4) A guaranteed annual supply of pure seed to all the farmers in the locality at a reasonable price. Accounts of the practical working of the system, the difficulties encountered and the provisions made for them are given. [*U. S. Dept. Agri. Farmers' Bull.* 1384. O. F. COOK and R. D. MARTIN.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. J. N. SEN, M.A., Ph.D., Supernumerary Agricultural Chemist, Pusa, has been granted leave on average pay for three months from 4th November, 1925.

MR. G. R. HILSON, B.Sc., Officiating Director of Agriculture, Madras, has been granted leave for eight months from the date on which his period of foreign service under the Government of Ceylon terminates.

MR. SADAT-UL-LAH KHAN, M.A., B.Sc., Deputy Director of Agriculture, Madras, has been confirmed in the Indian Agricultural Service from 24th January, 1925.

MR. F. SMITH, B.Sc., Deputy Director of Agriculture, Eastern Circle, Bengal, has been granted leave for three months from 27th November, 1925, Mr. J. N. Sarkar officiating.

RAI BAHADUR L. C. SHARMA, M.R.A.C., Deputy Director of Agriculture, Eastern Circle, United Provinces, was on leave on average pay for one month from 12th November, 1925.

Captain G. G. HOWARD, M.R.C.V.S., Deputy Director of Civil Veterinary Department, North Bihar Range, Muzafferpur, has been granted combined leave for ten months from 12th November, 1925.

MR. T. RENNIE, M.R.C.V.S., Veterinary Adviser to the Government of Burma, has been granted combined leave for 13 months and 3 days from 20th October, 1925.

MR. S. R. RIPPON, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, has been temporarily placed in charge of the office of Veterinary Adviser, in addition to his own duties.

MR. C. J. N. CAMERON, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, has been permitted to resign the Indian Veterinary Service from 29th December, 1925.

REVIEWS

The Growth of the Cotton Plant in India.—By R. S. Inamdar, S. B. Singh and T. D. Pande. (*Annals of Botany*, Vol. XXXIX, April 1925.)

This paper is an account of a series of experiments designed to test the relative rates of growth of cotton plants grown at different seasons of the year, with comparisons of the growth-rate with the leaf-weight and leaf-area ratios and with the respiratory indices of the plants. The growth-rate is measured by the increase in dry weight, and is the increase in dry weight per unit dry weight per week expressed as a percentage. The author finds that the growth-rate curve shows an initial increase, leading gradually or rapidly to a maximum, which is followed by a steep fall. The maximum growth-rate is not sustained for any length of time but is attained sooner or later according to the duration of the vegetative period of the plant, which is of course subject to variation from season to season. This variation of the vegetative period may be due to an inherent periodicity of the plant, modified to a greater or less extent by the environmental factors. In all the experiments which were carried out the flowering period commenced at a definite interval after the maximum increase in the growth-rate, namely, 27—35 days. The author suggests, therefore, that the maximum increase in the growth-rate supplies an internal stimulus for the plant to set itself to produce reproductive organs, the duration of the latent period being about one month in the variety of cotton (*roseum*) with which the experiments were conducted. On this view a profound physiological significance attaches to the period at which the maximum growth-rate is attained.

A growth-rate curve similar to that described in the present paper has been observed[1,2] for maize and *Helianthus* by Kidd, West and Briggs. These authors describe the growth-rate in these plants as being characterized by an initial fall, beginning at an early period in the life-cycle and succeeded by a sharp rise to a maximum growth-rate. The initial fall may be considered to mark the period during which the assimilatory organs in the young plant are unable to counterbalance the loss of dry weight due to respiration, thus giving a negative value to the growth-rate during this time. This negative value of the growth-rate does not appear to be so marked in the early stages of the cotton plant as in the corresponding period in maize and *Helianthus*.

During the second phase, in which the growth-rate is rising rapidly to a maximum value, Professor Inamdar finds that the curve of the growth-rate runs closely parallel

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[1] A Quantitative Analysis of the Growth of *Helianthus annus*, by F. Kidd, C. West and G. E. Briggs. *Proc. Roy. Soc.*, Series B, Vol. XII, 1921.

[2] A Quantitative Analysis of Plant Growth, by G. E. Briggs, F. Kidd and C. West. *Annals of Applied Biology*, Vol. VII, 1920-21.

to the curve of either the leaf-weight ratio or the leaf-area ratio ; this was to be expected as the period of greatest growth, in an ordinary annual plant without food reserves, must inevitably coincide with the period of greatest assimilatory activity, or in other words with leaf development. The attainment of the maximum growth-rate is succeeded by a period in which the growth-rate steadily falls, subject to the appearance of subsidiary maxima. The fall in the growth-rate in the last phase of growth is greater than is to be expected either from the decrease in the percentage leaf-weight ratio or in the percentage leaf-area ratio ; it may be attributed to a falling off in the assimilatory capacity of the leaves during the later stages of growth as has been noted by Briggs. It appears therefore that the growth-rate of a plant, as measured by the dry-weight method, is controlled by the leaf-weight or leaf-area, only for a short period, and that discrepancies between the growth-rate and the leaf factors appear as the result of variation in the assimilating capacity of the leaves and the production of flower-buds as opposed to foliage-buds. Since respiration results in a definite loss of organic material, an examination of the growth-rate relative to the respiratory indices of the entire plant, and parts of the plant, is of importance. The results obtained by Professor Inamdar with the cotton plant show that the respiratory index of the entire plant is highest in the early stages of growth and decreases steadily during subsequent stages. This is in agreement with the observations of Kidd, West and Briggs on *Helianthus*. There is, however, a discrepancy between the results obtained by these authors for the respiratory index of meristematic tissues in *Helianthus* and the respiratory index in cotton as determined by Professor Inamdar. In *Helianthus* [1] the respiratory index of meristematic tissue (stem apices) decreased rapidly from the 22nd to the 53rd day after germination ; this is contrary to expectation as we are dealing here with a tissue which, unlike the plant as a whole, is not complicated by increasing differentiation with age but is still meristematic and might therefore be expected to retain the original respiratory activity. It suggests that the fall in the value of the respiratory index of the entire plant is not entirely due to the increase, with age, of the proportion of non-living (mechanical and conducting) tissues but is the expression of some fundamental property of the protoplasm of the plant. In cotton Professor Inamdar finds that the respiratory index of meristematic tissue remains practically constant up to the 111th day after germination, even although there is a fall in the respiratory index of the entire plant during this period. In view of the contradiction between the results with cotton and those with *Helianthus* further observations will be necessary on the respiratory index of meristematic tissue in the former plant.

This paper is an interesting contribution to the quantitative study of plant growth, and the selection for the experiments of a plant of such economic significance as cotton certainly adds to the value of the work. This branch of plant physiology has been the subject of increasing attention in recent years during which several

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[1] Kidd, West and Briggs. *Loc. cit.*

workers have sought to apply to the phenomena of organic growth the mathematical formulæ which express certain types of chemical reaction.

Blackman [1] has suggested that the growth of an annual plant may be considered as a process following the compound interest law as expressed by the well known formula:—

$$Qt = Qo\varepsilon^{kt}$$

where Qt is the final weight at the end of time t,

Qo is the initial weight of the seed or seedling,

ε is the base of natural logarithms,

and k is the constant of increment.

The value of k in this formula is therefore an important physiological factor since it measures the efficiency of the plant in producing new material. According to this formula the increment of an organism in a given time is proportional to the magnitude of the organism and it is at once apparent that the rate of the production of new material in any one plant will depend, not only on a high value for k but also on a high value for Qo, the initial weight. Both of these factors are worth the consideration of the plant breeder, particularly in the breeding of cereals. The average seed weight in any one unit species is of course easily determined and a knowledge of the value of k might perhaps enable the plant breeder to make his selections on a more exact basis, and might afford an interesting insight into the causes of the success of certain unit species in particular areas.

A broad view of the problem of growth in plants and animals shows that it must consist essentially in the transformation of simple chemical substances into more complex entities. We have seen that in the growth of organisms we have a process which takes place at first slowly, later with greatly accelerated velocity, and later still as slowly as it began ; it becomes, therefore, of interest to enquire whether any chemical processes are known in which the rate of change resembles the growth process. Of course, many reactions of this type are known to chemists. For example, in the hydrolysis of cane sugar by (neutral) boiling water a certain proportion of mucic acid is formed which further accelerates the conversion of cane sugar into invert sugar ; all such chemical processes have this feature in common, namely, that one of the products of the chemical change which is going on has the power of accelerating the further progress of the change. These reactions are, therefore, autocatalyzed or self-accelerated, and it has been suggested[2] that the growth of organisms is similar to an autocatalytic reaction and can be expressed by the formula for such changes, namely —

$$\log \frac{x}{A - x} = k(t - t^1)$$

[1] The Compound Interest Law and Plant Growth, by V. H. Blackman. *Annals of Botany*, Vol. XXXIII, 1919.

[2] The Chemical Basis of Growth and Senescence, by T. Brailsford Robertson ; J. B. Lippincott Company, 1923.

where A is the maximum dry weight of the plant,
x is the dry weight at a time t,
t^1 is the time at which the weight of the plant is half the final dry weight,
and k is a constant of increment.

The fact that growth begins slowly and progressively increases in velocity up to a maximum indicates that the process of growth is autocatalyzed, and indeed the formula given above has been applied to such different subjects as the infantile growth cycle of man, the growth of the dairy cow and the growth of the sunflower, and has given a close agreement between observed and calculated values at different periods of the life cycle. A consideration of the formula for autocatalytic reactions in relation to the growth process of organisms will at once raise the enquiry as to how such a simple formula can express such a complicated process, for it is evident that in the building up of protoplasm many diverse and successive reactions must be concerned. It has been suggested [1], however, that in the complicated system of interdependent reactions which constitute the metabolism of the plant the slowest reaction will determine the velocity of the whole process and will become the " Master Reaction " governing the time relations of the whole. If, therefore, this master reaction can be represented by the autocatalytic formula then the whole process of growth will conform to this expression. Recently Mitscherlich[2] has formulated a law expressing the relationship between the yield of plants and the intensity of the external factors (*e.g.*, amount of manure) governing growth, but it is not within the province of this review to pursue further the researches of other writers. Work such as forms the subject of this review is gradually reducing the complex phenomena of growth to those mathematical terms which have been established as accurate expressions for reactions in the non-living world. At present we can scarcely foresee the practical applications in agriculture of the discoveries which await further research in the quantitative study of plant growth, but we may be sure that the greater the extent to which the phenomena of life can be brought under the mathematical laws which govern the non-living world the greater will be our power of control over vital processes. [F. J. F. S.]

The Agricultural Situation ; Economic effects of Fluctuating Price—By G. F. Warren and F. A. Pearson : (New York : John Wiley and Sons ; London : Chapman and Hall, Ltd.). Pp. xvi+306+106 text-figs. Price, 15*s.* net.

The book under review attempts to present in concrete statistical form all the pertinent facts bearing on the American agricultural situation and considers " the facts concerning the depression, the causes of it and possible remedies and to suggest changes in farm management that may help the farmer in so adjusting his practices as to enable him to meet the situation and be ready to make a profit when the depression is over."

[1] Robertson *Loc. cit.*
[2] Der Wirkungsgesetz der Wachstumfaktoren, E. A. Mitscherlich. *Landw. Jahrb.*, 1921-22.

It is an extraordinary fact that in spite of the present prosperity in the States in practically all branches of trade and industry, farming is in a very depressed state.

The authors hold that the basic reasons for the agricultural depression are financial inflation followed by rapid deflation : the disparity between farm prices and prices of things that farmers buy and payments of taxes, interests and debts. The change in the value of money, though the major cause, the *lag* of wages, and the *lag* in taxes and interest becomes each in turn the cause of many other difficulties. Since the farm depression is mainly a price problem the effective remedy lies in a proper and quick adjustment between the prices of the things the farmer sells and the prices of things he buys and between the prices of things he sells and taxes and public and private debts. The maintenance of a general price level that is adjusted to freight rates, taxes and pay of public employees and to the price level when debts were incurred is therefore necessary. The authors suggest the appointment of a commission by Congress to make a scientific study of the relationship of the different classes and determine the price level that will result in the least total injustice and to study the feasibility of various methods of obtaining a reasonable degree of price stability.

In the first 75 pages is given a historical treatment of the extent and causes of the agricultural distress. Next follows in about 150 pages a careful and exhaustive collection of farm, retail and wholesale prices of, and index numbers for, most of the farm products. Chapters are added on farm wages, value of land and the effects of the depression. The volume concludes with authors' suggestions and advice as to how farming should be adjusted to deflation.

The book, though written with a set purpose and with a typically American outlook and though Indian agriculture is still almost self-contained and neither so specialized nor so commercialized as American agriculture, is not without interest to India especially in view of the Taxation Enquiry Committee and the Economic Enquiry Committee constituted in this country.

NEW BOOKS

On Agriculture and Allied Subjects

1. Coffee : A Monograph of the Economic Species of the Genus *Coffea* L., by R. H. Chency. Pp. xvii +244. (New York : The New York University Press.)
2. A Catalogue of British Scientific and Technical Books. New edition. Pp. xxii+ 489. (London : The British Science Guild.) Price, 12*s*. 6*d*.
3. Anatomy and Physiology of the Honey-Bee, by R. E. Snodgrass. Pp. xv +327. (New York and London : McGraw-Hill Book Company.) Price, 17*s*. 6*d*.
4. The Culture of Lucerne, by W. S. Hill. Pp. 266. (London : Whitcombe and Tombs.) Price, 7*s*. 6*d*.
5. An Introduction to Sexual Physiology ; for Biological, Medical and Agricultural Students, by F. H. A. Marshall F.R.S. Pp. xii + 167 ; 72 figs. (London ; Longmans, Green & Co.). Price, 7*s*. 6*d*. net.
6. Statistical Methods for Research Workers, by R. A. Fisher. Pp. ix + 239. (London : Oliver & Boyd.) Price, 15*s*. net.

THE following publications have been issued by the Imperial Department of Agriculture since our last issue :—

Memoirs.

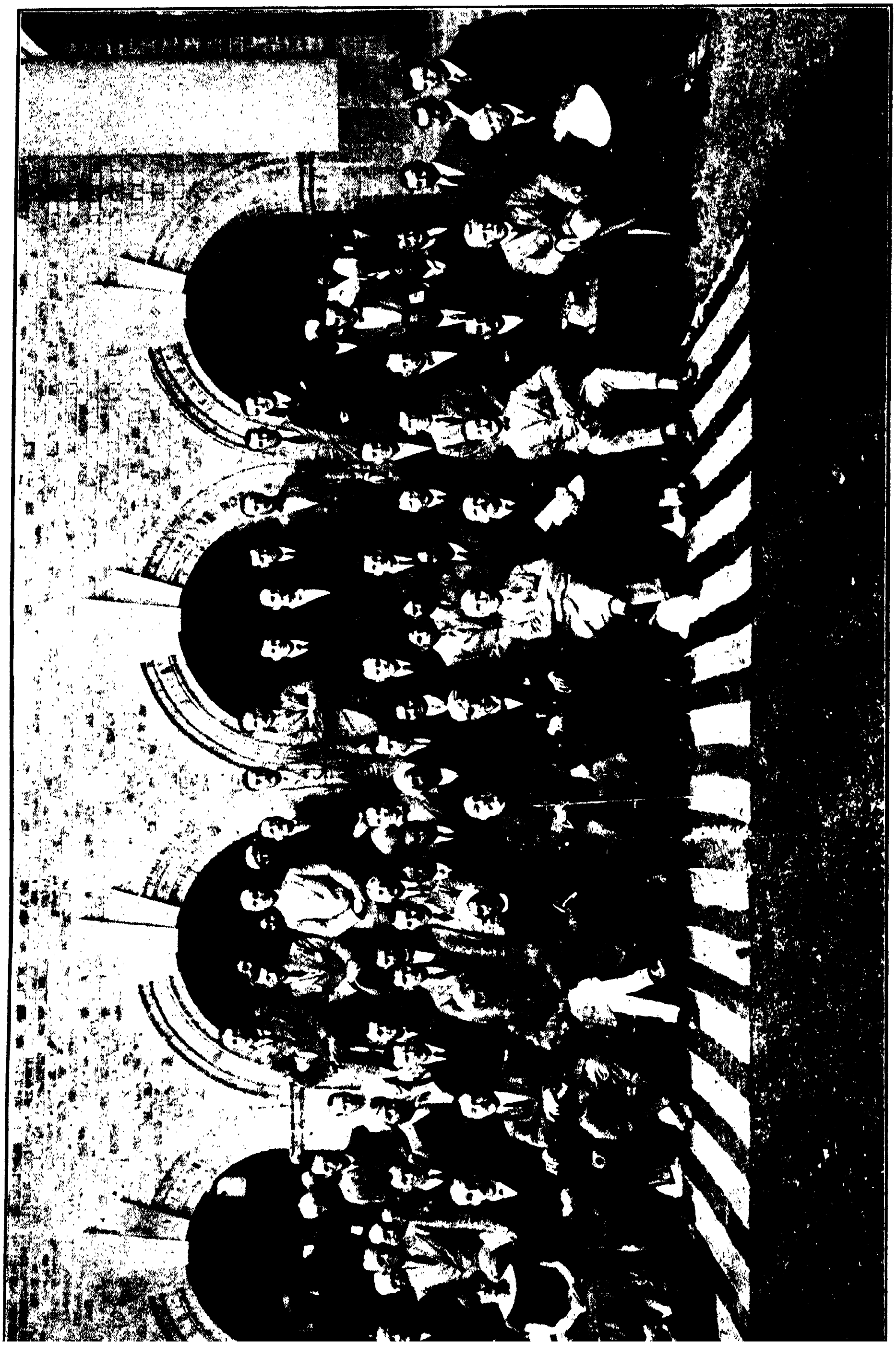
1. A Study of Some Indian Grasses and Grasslands, by W. Burns, D.Sc., L. B. Kulkarni, M.Ag., and S. R. Godbole, B.Sc., B.Ag. (Botanical Series, Vol. XIV, No. 1). Price, As. 12 or 1*s*. 3*d*.
2. Nitrogen Recuperation in the Soils of the Bombay Deccan, Part I, by D. L. Sahasrabuddhe, M.Ag., M.Sc., and J. A. Daji, B.Ag., B.Sc. (Chemical Series, Vol. VIII, No. 5.) Price, As. 4 or 5*d*.

Bulletins.

3. Publications on Indian Entomology, 1924 (compiled by the Imperial Entomologist). (Pusa Bulletin No. 161.) Price, As. 8 or 9*d*.
4. Loss of Sugar by Inversion in Sugar Factories in Northern India and its prevention by Antiseptic Measures, by C. M. Hutchinson, C.I.E., B.A., and C.S. Ramayyar, B. A. (Pusa Bulletin No. 163.) Price, As. 2 or 3*d*.

Report.

5. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau), for the year 1924-25. Price, Rs. 2-4 or 4*s*.



BOARD OF AGRICULTURE IN INDIA, PUSA, DECEMBER 1925.

EDITORIAL

FOURTEENTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA.

[*Pusa, 7th—11th December, 1925.*]

LATELY agriculture in India has received more than usual attention in the press of both England and India, probably owing to the reported opinions of both the Secretary of State for India and the Viceroy-Designate. That it is a subject which is of not only the first importance but one on the development of which the whole of India depends, needs little or no emphasis at the present time.

India possessing as it does such advantages in climatic and soil conditions, should, with more extensive irrigation projects, the supply of improved seeds, etc., and more important still, the betterment of the existing breeds of cattle, very considerably increase her potentiality for the economic production of crops and thus add largely to her wealth resources. This would naturally have an effect not only on the agricultural aspect of the country, but would result in a general uplifting of the standard of living amongst the mass of the population of the country—a consummation devoutly to be wished.

The speech of the Hon'ble Sir Muhammad Habibullah, Member in charge of the Education, Health and Lands Department of the Government of India, at the inaugural meeting of the Board of Agriculture in India at Pusa on 7th December, 1925—which was largely attended and included a number of distinguished visitors—was one of confidence in the work that had been accomplished and of optimism for the future. He rightly emphasized the fact that while the study of scientific agriculture was of the first magnitude to this country, there were other more or less side-issues which were of great importance, such as the making of increased facilities for marketing, the study of the value of co-operation in its various forms, etc. A broad view was therefore essential when considering this—India's most important industry—and it was this view which the Government of India were keeping before them in their efforts to improve the conditions prevailing in this great Indian Empire. For this end, the findings of the Board ot Agriculture in India, he felt sure, were of the greatest value to the Government who after reviewing them were prepared to carry out suggestions as far as compatible.

The address of the President of the Board, Dr. D. Clouston, Agricultural Adviser to the Government of India, was first marked by his calling on the Board to pay a last sad tribute of respect to an old member of the department—the late Prof. Maxwell-Lefroy, whose name must be added to that long Roll of Honour of those who had sacrificed their lives for the advancement of science.

Referring to the subjects which were on the agenda before the Board, the President made a very careful and analytical survey of them, and suggested lines of discussion which might prove useful in elucidating some of the problems which would naturally arise during the debate. These subjects covered a large amount of ground and were of such a general nature as to be of importance in some aspect or another to every member and visitor. Before the actual discussion of these by the Board, the President formed Sub-committees for their separate consideration, of those members who were most interested in each. By such means definite proposals for lines of research and improvement could be obtained, and these proved of very considerable value to the Board in its subsequent discussions.

The first subject considered was the question of the improvement of tobacco, a crop which was, as the President pointed out, of very considerable economic importance to India, especially at present when the Empire preferential import duty had just been considerably reduced. After some discussion, the general feeling of the Board was manifested in its confirming the proposed resolution of the Committee (1) to establish a Central Tobacco Bureau at Pusa, and (2) to appoint a Curing Expert according to the lines laid down in the Committee's report. As very little has been done in the past or can be done in the future by the provinces and Indian States without such help, these recommendations are steps in the right direction and, while involving little in the way of extra expenditure, should prove of great value to all interested in the crop.

The advisability of establishing closer relations with the International Institute at Rome was then taken up by the Board. To the average layman it might appear that this had little to do with India and was relatively unimportant as regards the general scientific improvement of her agricultural industry. But a careful study of the very large amount of work this Institute has done and is doing and the great help which India could derive from it, would prove that this subject was well worthy of the Board's earnest consideration. Apart from its publications and its supply of information on agricultural statistics, the Institute is willing to undertake any special enquiries for any of the contributing countries, of which India is already one. Others of its functions which would be of very great importance to this country are full information about the various types of agricultural legislation, rural economics, statistics and many other subjects connected with agriculture. The fact that this information is culled from the details and experiences of the seventy various States which are now contributing to it, proves of what immense value such information would be to a country like India where, despite the fact that agriculture is her basic industry, only now are efforts being made to break through her old fashioned conservatism and bring her into line with more modern agricultural development. This was the view that the Board took after due consideration of the question and was embodied in their final recommendation.

When the next subject came up for discussion, *i.e.* agricultural middle schools —their progress and the experience gained since 1922, there seemed to be a fair

divergence of opinion. That there was a demand for some sort of agricultural education was generally felt, but the problem was one which would be better left to each province to decide about, rather than lay down a general method. The system of teaching agriculture in vernacular middle schools, at present being carried out and extended in the Punjab, has met with considerable success and would very probably prove of considerable use in some other provinces. In Bombay, again, the vocational agricultural school has achieved some measure of success. For all India, however, it would be inadvisable to say whether one or other type should be adopted. The Board, therefore, limited itself to a general recommendation that the training given in agriculture should be of such a nature as to make the boys' minds better prepared to receive agricultural training and to arouse their interest in agriculture and its possibilities.

That wild animals are responsible for an enormous amount of damage done to crops no one will deny. The subject of what steps could be taken to save crops from the depredations of wild animals, therefore, needs no explanation for its appearance on the agenda before the Board. It was pointed out that valuable work had been and was being done in the Punjab in an effort to systematically carry out the destruction of field rats. Patiala State had also evolved a method for destroying this pest by fumigation. In Bombay, too, a Committee had been formed which had made several useful suggestions particularly with regard to forming fencing societies against the wild pig. On the whole, however, experience was meagre, and members were generally of the opinion that while something ought to be done as early as possible, the best way to tackle the problem would be to study the life-history of some of the more destructive, such as the wild pig, in order that the weak points at which they could be attacked could be found out. Only then could successful methods be recommended for the control of wild animal pests.

Of all the subjects before the Board, the last to come up for discussion was, apart from the fact that it consisted of six parts, by far the most important. It dealt with the various aspects of animal husbandry and dairying ; the importance lay in the fact that cattle are the very back-bone of Indian agriculture.

It was therefore very encouraging to hear of the various efforts that were being made throughout all the provinces and most of the major Indian States to improve the various breeds of cattle both for milking and draught purposes. This progress was real but would of necessity be slow, as the problem was one that would take time in carrying out the very large number of experiments and trials necessary before a good breed for a particular tract and purpose could be evolved. Much useful information regarding cross-breeding was also placed before the Board by the Imperial Agriculturist, the Imperial Dairy Expert, Col. Marriott, head of the Military Dairy Farms, and Col. Matson.

Wrapped up with the question of cattle-breeding is the important question of forage. Amongst the most useful methods of conserving this during times of abundance, *i.e.*, during the monsoon, silage must of necessity prove an important one.

It has long been recognized as such in other countries, and since many pastural lands throughout India are being gradually taken up for crop cultivation, the question of fodder supply is naturally becoming acute. The well known conservatism of the Indian ryot against new methods will of course have to be overcome, and the importance and economic value of growing a fodder crop, instead of a grain crop, will require much demonstration ; but the urgent necessity of finding some solution to the problem is slowly being recognized. The method therefore of conserving fodder crops and grasses in silos is one that will well repay study and demonstration.

Since the last meeting of the Board, one of its recommendations to the Government of India has been carried out and that is the formation of a Central Cattle Bureau—a most important advance in the general development of cattle-breeding in this country. The present Board considered however that an all-India Committee or Board consisting of experts was essential to control it, as it was felt that the Central Cattle Bureau could not fully benefit the Indian cattle industry unless all Provincial Governments and important States shared in its control.

The importance of animal husbandry and dairying being of such magnitude, it was only reasonable to expect the Board to consider every means of carrying out such improvements as could be thoroughly recommended. For this purpose the Co-operative Departments in many provinces were being called in to assist the Agricultural and Veterinary Departments. It was, in the opinion of the President, impossible to over-estimate the value of such work, and the Board generally considered that co-operative societies were not only of value in propaganda work but provided a very useful means of getting improvements carried out ; while in marketing such products as dairy produce, better control could be obtained, waste was avoided, and the producer obtained a better value for his produce.

A further part of this subject was the consideration of what steps could be taken to combat outbreaks of cattle disease. This at the present time is particularly important as just recently parts of the country have been swept with the disease-rinderpest, and the loss, though not known accurately, must have been very heavy. The Board was assisted in this by a number of expert veterinary officers from the Central and Local Governments, and while the discussion was naturally somewhat technical it was obvious that much research work of first importance was and is being done to combat the more important diseases of cattle and the results already obtained are in active application in many provinces.

The last part of this subject before the Board was to determine whether the time had come for the training of men for the Indian Dairy Diploma. Considerable discussion took place and there was also some divergence of opinion as to whether there was a demand for such men in the various provinces and Indian States. The Imperial Dairy Expert had strong evidence that there was a demand for such men, but as he pointed out they must be practical men and the course of training laid down at Bangalore was very largely of this nature. Even, however, if the demand for practical dairy men is not very large at present, there can be no doubt that local

requirements are bound to increase before long. It is therefore essential that some efforts should be made to have trained men ready to meet this demand.

While this concluded the subject matter put up for formal discussion by, and opinion of, the Board, it should not be overlooked that these meetings serve another and very important purpose, in that they form a clearing house as it were, of ideas regarding lines of research in the innumerable problems that face all members of the Department of Agriculture, both Central and Local. Thus while it cannot be denied that the findings of the Board are all important, neither can it be said that these informal arguments and exchange of ideas amongst members and visitors are not of equal importance in the joint and individual efforts to improve the agriculture of India generally, and the solution of the individual problems which are continually arising.

Finally, the work going on at the Pusa Institute, which must be regarded as the centre of all research work in agriculture in India, is of such importance to all provinces and States that the opportunities given to the Board to inspect the various Sections, while invaluable, were all too few owing to the shortness of the time available, to thoroughly inspect the all important and excellent work at present being undertaken. Suffice it to say that every member and visitor made a special point of visiting those Sections in which he was particularly interested and carrying away from them such ideas regarding research as might be useful for the particular problems with which he was confronted.

In this connection too much stress cannot be laid on the trouble which the various Heads of Sections took in explaining the work in hand and answering the numerous questions that were asked by various enquirers. Among the innovations, the utilization of the cinematograph for propaganda work was very much appreciated. Mr. Hutchinson, the Imperial Agricultural Bacteriologist, who has taken up this work, produced some excellent films contrasting local with modern methods of agriculture, and proved conclusively that the cinema must be allotted an important place in carrying out this important branch of modern agricultural development.

When, finally, the excellent programme marked out by Dr. Clouston, the Agricultural Adviser to the Government of India, had been concluded, all those who had had the privilege of attending felt that not only had this the 14th meeting of the Board of Agriculture in India been very interesting and enjoyable, but that one's general outlook had been broadened, new ideas for research work gained and fresh stimulus had been given to further increase one's efforts for the uplifting and improvement of agriculture in India and bringing it more into line with modern development. Such an object must be regarded by all classes of the community as of the first importance, since agriculture provides not only the means of livelihood for by far the greatest number of her people, but as India's greatest industry must provide the largest part of any resources required for any and every branch of the country's development.

M. CARBERY.

Presidential Address.

Dr. Clouston, in his introductory speech, said :—

" LADIES AND GENTLEMEN,—I desire to extend to you all—members and visitors —a hearty welcome to this, the 14th meeting of the Board of Agriculture in India. I desire in particular to welcome the Hon'ble Sir Muhammad Habibullah, Member for the Department of Education, Health and Lands. His presence here to-day is one more indication of the ever-increasing interest which the Government of India is taking in the economic development of India's premier industry—agriculture. I have much pleasure also in welcoming the Hon'ble Sir Saiyad Muhammad Fakhruddin, Mr. Calvert, Colonel Marriott, Colonel Matson, Captain MacGuckin, Mr. Nagarkatti and others, some of whom have come long distances to attend our meeting and to give us the benefit of their experience.

" In opening our meeting it is my sad duty to refer to the loss sustained by the scientific world in the death of a former member of the department and a personal friend to many here, who has passed away since last we met. I refer to the late Prof. Maxwell-Lefroy. Prof. Maxwell-Lefroy was one of the pioneers who helped to lay the foundation of the science of agricultural entomology in this country. His death adds one more name to the long list of those who have given up their lives for the advancement of science. I would request the Board to formally express its sympathy with his wife and son in their bereavement, and to agree to an extract of these minutes being sent to them.

" Since last we met, several of our old members have retired from the Service to finish their life's work in other lands. We regret in particular the loss of Mr. Milligan who, during the tenure of his office, presided twice over the deliberations of this Board. The department has, for the last few years, been beset with many discouragements ; but I feel that the dawn of better days is at hand. You have no doubt read the pronouncements made by the Secretary of State for India and His Excellency the Viceroy on the desirability of developing on scientific lines India's basic industry—agriculture. You will have noticed, too, that the press both in England and India have laid great stress on the significance of these pronouncements. The leading newspapers in this country have always been true friends of the department, and have, from time to time, brought to the notice of their readers the importance of the work which is being done for the betterment of the tiller of the soil. We only hope that in course of time our leading landowners will also realize that the moral and material welfare of this Great Empire is largely dependent on the advancement of agriculture, which provides a livelihood for three out of every four of her people, and which provides as well the materials required for the development of most of her other industries.

" But advancement must be based on new knowledge—the foundation of progress in agriculture as in other industries. There is only one way of wresting from Nature this knowledge as to how improvements can be effected, and that is by scientific

research. There is a very real danger in these days of the importance of research being lost sight of, and of our demonstrating the same old improvements year after year, for want of anything new to demonstrate. What our department most urgently requires, in short, is the better organization of research and better facilities for training investigators in order to supply the knowledge on which continuous improvement in every branch of agriculture can be based.

"Agriculture has not as yet attracted a fair share of the brains, capital and enterprise available in this country and never will, until and unless we get the educated land-owning classes to interest themselves in its development. We only hope that the considered opinion lately expressed by those in authority with respect to the paramount importance of agriculture as the premier industry of India will help towards that end. In the realm of husbandry we want hundreds of leaders of the stamp of Sir Ganga Ram and Mr. Roberts of the Punjab—men of brains, imagination and capital—to raise the standard of agricultural practice to a higher plane and to establish the farming industry on a sound economic basis. But until such men come forward in adequate numbers Government will, in the interests of India, have to provide the driving and organizing power at every stage of advancement.

"Since last we met, recruitment from abroad to the Indian Agricultural Service has been stopped, and provision has been made at Pusa and Bangalore to train men for the highest posts in the department. The control of the Cane-breeding Station at Coimbatore has been taken over by the Government of India, and the station extended as regards both area and staff. An Institute of Plant Industry has been established at Indore and work started on cotton and other crops. Under the unpretentious title 'Crop Production in India' Mr. Howard, Director of that Institute, has given an inspiring record of the departmental and research work done within the last 20 years by scientific workers in the field of Indian agriculture, and reviewed some of the problems awaiting solution. The Technological Laboratory of the Indian Central Cotton Committee formally opened by His Excellency the Viceroy last December, is now rendering assistance to the cotton workers in the provinces. The Agricultural College at Mandalay in Burma was opened in July last year.

"Turning now to the subjects for discussion we find that problems relating to cattle-breeding figure largely on the agenda. This is as it ought to be, for in Indian agriculture cattle play a larger part than they do in most countries. But any improvement of our herds must be preceded by an improvement of the fodder supply. In the past when large grazing areas were available, the cultivator relied very largely on Nature to provide food for his cattle in the form of pasture. In course of time the increase in population and consequent reduction in pasture lands gave rise to rural problems which were new to him. The ever-increasing population demanded more bread, and the most obvious way of providing it was to increase the area under cultivation by encroaching on village grazing areas. In many parts of India the cultivator has not yet learned to readjust his system of farming to meet the new

economic conditions which have thus arisen. In the more advanced parts of the country, where grazing areas have been reduced to a minimum, fodder crops are being grown to some extent ; but in the more backward parts, where grazing areas are large, no provision is yet being made, either for growing or storing fodders.

" Agricultural progress over the greater part of rural India is still handicapped, in short, by the fact that there is not enough fodder grown to meet the requirements of the cattle required for milk and draught. Further, cattle-owners do not, as a rule, make any effort to carry over the surplus fodder available at the end of the rains, for use in the hot weather when pasture lands are parched and bare : nor do they carry over surplus fodder available in years of plenty for use in years of shortage. The Agricultural Department has of late years given much attention to the question both of growing and storing fodders : in this it followed the fine example of the military dairy farms which have long been models of their kind. Several very promising fodders have been introduced and methods of storing them in the dry state or as ensilage adopted. It has been definitely proved that palatable ensilage can be made from coarse grasses, weeds and other herbage which in most parts of India are available in considerable quantities towards the end of the rains.

" As regards the improvement of cattle by better breeding, the Imperial and Provincial Departments of Agriculture and some of the more advanced Indian States have drawn up schemes based on the assumption that there are too many scrub half-starved cattle in the country, and that what is wanted is an improvement in the quality of our live-stock. The different breeds are, therefore, being studied and pure-bred herds established, with the view of providing a foundation whereon the cattle industry, both as regards draught and milk, can, in course of time, be raised. Given this foundation, it is possible to build up herds of pure-bred pedigreed cattle possessing the characteristics required to meet the economic needs of India. With a view to stimulating and to some extent co-ordinating the efforts being made towards cattle improvement, the Government of India have decided to give effect to the recommendations made by the Board of Agriculture in 1924, and to establish a Central Bureau of Animal Husbandry. The control of this Bureau will be vested in the Imperial Dairy Expert and its headquarters will be his office. The proposal is that the main duties of this Bureau to commence with should be (1) to collect and disseminate information concerning cattle-breeding and allied subjects, (2) to assist in the disposal of surplus pedigreed stock available on Government cattle-breeding farms, (3) to standardize breeding records and methods of milk recording, (4) to maintain general herd-books of breeds, or of milch cattle as distinct from specific breeds found in more than one province or State, (5) to encourage the use of pedigreed stock, and (6) to keep the officers in charge of cattle-breeding in provinces and Indian States in touch with each other. It is hoped that Agricultural Departments, as well as private individuals interested in the cattle industry, will co-operate with the Imperial Dairy Expert in his efforts to make this Bureau of real value.

"As example is better than precept, I would strongly advise those of you who are interested in animal husbandry, to inspect the provision made for growing and storing fodder on the Pusa farm, and I should like you to see also the cinema films prepared by Mr. Hutchinson to illustrate how silage is made. I trust that our fine Pusa herd improved by selective breeding, cross-breeding and careful feeding will convince you that there is a great future for the cattle industry in this country.

"Until, however, the apathy of Indian landowners towards rural economics generally is broken down, cattle-breeding as well as other branches of husbandry will continue to be neglected, and the high standard of cattle-breeding and cattle-feeding being demonstrated on Government farms will be of little avail. This apathy can, we believe, be broken down by giving the sons of landowners a more scientific and practical education ; for we believe that the type of literary education given them in the past has tended to alienate their sympathies from agricultural pursuits. It is hoped that in course of time the type of agricultural education provided for at our agricultural colleges and the Institute of Animal Husbandry and Dairying at Bangalore will, based as it is on practice as well as theory, go far to foster a practical interest in cattle-breeding and dairying. We are to consider whether the time has now come for Provincial Governments and Indian States to provide a course of training similar to that which is being given at Bangalore for the Indian Dairy Diploma.

"Animal husbandry is of such outstanding importance in India that our bounden duty is to get all the assistance possible, in solving its problems. We are, therefore, to discuss the extent to which Co-operative Departments can co-operate with the Agricultural and Veterinary Departments in attaining the end we have in view.

"We are to consider, too, what further steps if any can now be taken by Government to combat outbreaks of cattle disease— rinderpest in particular. The serum-simultaneous method of preventive inoculation is admittedly not free from risk. The Board will, I hope, give an opinion as to whether it will pay in the long run to take this risk in order to give permanent immunity against India's most serious of cattle diseases.

"Another subject on which we are to deliberate at this meeting is the utility of agricultural middle schools. The same subject was discussed at considerable length by the Board in 1917. At that meeting we arrived at the conclusion that while rural education was primarily the business of the Education Department, a limited number of agricultural schools should be opened as an experimental measure, in view of the possibility of a demand for a purely agricultural education arising. The subject was again considered by the Board in 1922, and the conclusions arrived at were that although the special schools of the type recommended in 1917 had not been successful generally, further experiments were necessary. Attention was drawn, moreover, to the fact that a scheme to provide agricultural training in ordinary middle schools had met with a considerable measure of success in the Punjab. Nearly four years have passed since this subject was discussed, and it is, therefore,

desirable to examine and report on the progress made and experience gained during that time.

"Another subject on the agenda is the improvement of Indian tobacco. There is in this country a great demand for a cigarette tobacco possessing the flavour of the imported Virginian cigarette. The varieties of tobacco indigenous to India give a somewhat coarse leaf which, to some extent, meets the local demand. The demand, however, for tobacco of a finer grade is increasing. In 1923-24 India imported cigarettes, cigars and tobacco leaf of the value of 226 lakhs of rupees; she exported in the same year tobacco worth Rs. 1,02,97,000. The possibilities of developing a bigger export trade, particularly with Great Britain, is greater now than ever before, consequent on the fact that Great Britain has reduced her customs duties on Empire-grown tobacco; but the type for which there is a keen demand abroad is that required for the manufacture of cigarettes, namely, a tobacco of the colour, flavour and texture of Virginia. I should like the Board to advise as to how we can most effectively assist tobacco-growers to take advantage of this ever-increasing demand for tobacco of better quality. It may be desirable to give more attention to tobacco-breeding with a view to evolving types giving a finer quality of leaf: it may be desirable, too, to give increased attention to the technique of curing, fermentation, etc.

"Subject 4 on the agenda deals with the question of how to save crops from damage by wild animals. The amount of damage done by such animals as pigs, deer, jackals, monkeys, etc., is enormous, owing to the fact that the cultivator either will not, or cannot prevent it. The problem is rendered all the more difficult by the fact that he finds it expensive to fence his different fields scattered over the village area. Still I have noticed that within the last 15 years a demand for patent woven fencing has arisen, and that considerable quantities of it are now being used in some provinces for the protection of the more valuable crops.

"The last subject on the agenda refers to the activities of the International Institute of Agriculture at Rome. India is represented on this International Institute; but the opinion has been expressed by delegates who have represented India at its meetings, that the Institute is badly supplied with information concerning the development of agriculture in this country. There is a feeling that if India could exercise a greater influence on the policy of the Institute, it would be possible to get it to publish information concerning tropical agriculture in which India along with other tropical countries is so deeply interested. The Board may be able to suggest ways and means of establishing closer relationship with the Institute. The provisional agenda for discussion at the General Assembly of the Institute next May has been sent to us for consideration. It will be the duty of the Board to discuss this agenda, and to suggest the attitude which should be taken up by the delegates from India who attend the Assembly.

"It is now my privilege to request the Hon'ble Member for Education, Health and Lands to address the Board."

PLATE V.

THE HON'BLE SIR MUHAMMAD HABIBULLAH SAHIB BAHADUR, ~~Kt., K.C.S.I.~~ K.C.I.E, Kt

Member in charge of the Department of Education, Health and Lands, Government of India.

Sir Muhammad Habibullah's Speech.

THE Hon'ble Khan Bahadur Sir Muhammad Habibullah, ~~Kt., K.C.S.I.~~, then addressed the Board as follows :—

"GENTLEMEN,—I accepted with alacrity the invitation of your President to attend this meeting of the Board of Agriculture mainly for two reasons. In the first place, I was eager to convey to you in person the great interest evinced by the Government of India in all problems which conduce to the happiness and prosperity of the agricultural population of this pre-eminently agricultural country. In the second place, I could not resist the temptation to seize the earliest opportunity of meeting so many enthusiastic workers—official and non-official—engaged in agricultural and veterinary work in British India and in the Indian States. It is, in my opinion, the most useful, if not the main, function of these biennial meetings to afford agricultural and veterinary officers an opportunity of discussing their respective activities ; they act as a clearing house of agricultural information and as a means of keeping you all, separated as you are by great distances and working under diverse conditions, in touch with one another. I have listened with deep interest to Dr. Clouston's admirable speech, reviewing the items of work which await your consideration, and I feel reluctant to indulge myself in making any observations of my own ; but I trust that you will bear with me when I claim that, as one connected with a province which is predominantly agricultural and having had opportunities of coming into contact with agricultural conditions, it will be my earnest endeavour to contribute my share, however small, as Member of the Government of India in charge of Agriculture, in the development of this the greatest and the most important of Indian industries.

"We are now, I trust, emerging from the financial stringency which, as an inevitable result of the Great War, had rendered fresh expenditure on Agricultural Departments in India well-nigh impossible. The fact that in spite of this embargo, Provincial Departments have, during the past five years, increased instead of curtailing their activities is, to my mind, a striking tribute to the persevering efforts of Provincial Governments and the unflagging zeal of the agricultural officers serving under them. The Government of India, on their part, have also, in the face of adverse financial circumstances, tried to contribute their quota in that direction. As you are aware, the institutions at Pusa and Muktesar have not only been maintained but have been materially expanded. Three dairy farms, at Wellington, Karnal and Bangalore, have been taken over from the military authorities. Their activities and those of the Institute of Animal Husbandry and Dairying at Bangalore are so well known to you that it is needless for me to enlarge upon them. We have in addition recently taken over the military creamery at Anand and propose to run it as a dairy factory school. The Coimbatore Sugar Research Station has been brought under Imperial control and proposals have been sanctioned for its substantial expansion during the current year. We have also, as you are doubtless aware,

steadily kept in mind the claims of agricultural education, especially in regard to veterinary and animal husbandry and dairying. Last, but not the least, it was in the year 1921 that the Government of India took steps to constitute the Indian Central Cotton Committee, whose activities, in these few years, have been of immense benefit not only to the Indian cultivator of cotton but also to the cotton trade in general. These activities of the Imperial and Provincial Departments of Agriculture are all the more remarkable as, owing to causes which I need not recapitulate, Departments of Agriculture in India have, during this period, lost the services of some of their most eminent and experienced officers. I am, however, happy to notice that, as a result of the labours of the Lee Commission, of which I had the honour to be a member, the considerations which largely contributed to this unhappy result have been greatly minimized, and we may confidently hope to count, in future, on a sufficiency of suitable officers.

" We are now, I think, in a position to take stock of the situation. In the comparatively short period, during which the Imperial and Provincial Departments of Agriculture have been at work, most of the staple crops of the country have been improved by selection and crossing. Over five million acres are now being sown every year with improved varieties and strains. Thousands of agricultural implements and labour-saving machines, which have been tested and approved, are being supplied annually. The various breeds of cattle are being improved by selective breeding and better feeding ; prophylactic measures have been introduced on a large scale to protect them against disease ; crop pests and diseases have been studied and remedies devised ; organizations for propagating and distributing improved seeds and for supplying agricultural implements, machines and manures have been built up. These are but a few of the outstanding results of the labours of the Agricultural and Veterinary Departments in this country working in conjunction with Co-operative Departments ; and, handicapped as we have been both by the need for economy and by the shortage of officers, you will, doubtless, agree that this is no mean achievement. There is, however, another side of the Indian agricultural problem which needs examination and solution. It is not enough, to use a homely phrase, ' to make two blades grow where one grew before ' although I confess it means a great deal. We should, at the same time, ensure that the crops so grown can be sent expeditiously and cheaply to places where they are required, and that the man who grows them should get an adequate return for his labour. In short, the importance of the questions relating to transport of agricultural produce and the provision of cheap credit to the cultivator cannot be sufficiently emphasized. I realize that in a country like India, with its 7 lakhs of villages and with a population of 319 millions, it is by no means an easy problem to tackle ; but I feel confident that the efforts so far made in this direction, will receive further stimulus.

" The rural problem has numerous aspects. Each of us is working on our own facet of it. We are like members of a team. From our own special angle, we are all making our contribution towards the same high object ; that object is the welfare

of the great mass of the population of this country, whose livelihood depends on the land. We must remember to take broad views and long views. We must think not only of the innumerable problems connected with the production of good crops, but we must think also of the transport of that produce to market and of its marketing. We must consider how the whole process is to be financed, and as our range widens, we must take count of those great and difficult problems connected with the growth of population and the increasing pressure on the land. We must extend our interest to the problems connected with rural education which should make our rural population not only good men and good women but also good agriculturists; rural sanitation which should help to reduce the grave mortality in many tracts of the country, especially among children, and the improvement of the village system. It is only when the problem is envisaged in its widest bearings that we can each realize our own line of work in its true perspective. However specialized the line of work may be, that any of you is pursuing, the validity and value of your conclusions must be greatly affected by a correct appreciation and correlation of its bearing on all other forms of agricultural improvement. In the provinces, therefore, the officers of the various departments, engaged in progress among the agricultural classes, should maintain the closest touch with each other and work in intimate co-operation. Similarly, as between provinces, some measure of co-ordination is desirable and duplication of work should be avoided.

"There is another point to which I would desire to invite public attention: I refer to the imperative necessity of encouraging our educated young men to realize that agriculture also affords an opening for an honourable and prosperous career in life. I do not refer now to their legitimate ambition to take up appointments in the Agricultural Departments, but to the desirability of their taking up farming as a profession. The underlying aim of our agricultural colleges is not merely to provide recruits for our Agricultural Departments but mainly to turn out good, scientific and up-to-date farmers. We desire that the students in our agricultural colleges, after completing their course, should utilize the knowledge they have thus gained, by taking to agriculture as a profession. After all, very few of those who pass out of the agricultural colleges can be absorbed into Government departments. Moreover, there is great need in the country for a nucleus of educated men who have made farming their profession, and it is these men who can, by their example, disseminate among their less fortunate brethren a knowledge of the modern improvements in agricultural practice. Hitherto, Governments in India, through their demonstration farms, have tried to do this work; but the resources of no Government can be so large as to undertake such a gigantic task. There is a wide field for private effort in this essential direction. And here I would make an earnest appeal to the big landowners to co-operate with Government in this laudable sphere. The agricultural prosperity of England, while it was still a predominantly agricultural country as India is to-day, is largely due to the efforts of her big landowners, and is it therefore too much to expect that the big landowners in India will realize their

responsibilities and serve as pioneers in raising the standard of agricultural practice and, by the force of their example, influence the masses of the rural population to follow in their wake ?

"I should like, once again, to express my great pleasure at having had this opportunity of meeting you all. The recommendations of the Board of Agriculture have, in the past, been of the greatest value to the Government of India and I am sure also to the Provincial Governments, and many of them have been carried into practice with gratifying success. I am confident that your ensuing deliberations will have an equally fruitful result. Interest in Indian agriculture has recently, as a result of the pronouncements of the Secretary of State and of His Excellency the Viceroy, been greatly stirred, and, if I may hazard an opinion, we are, I think, now on the threshold of an era of agricultural development which will, in course of time, place Indian agriculture on the same high plane as it is now in Europe and America, and which will contribute to the lasting prosperity of the rural population of India, and, through them, of our country.

"And now, Gentlemen, it only remains for me to thank all those who have been responsible for the success which, so far, has been achieved. I realize that, in a big venture like this, it is somewhat difficult to select for special mention those earnest and enthusiastic workers who, in their own spheres, have ungrudgingly and loyally devoted themselves to their respective tasks in a manner to call forth the highest admiration. Some of them have worked against odds ; some in environments which were uncongenial to their scientific labours, and some others again in combating a conservatism which had survived for ages. If I may be pardoned for any personal reference, I cannot help feeling that it would be ungenerous on my part if I fail to acknowledge, on this occasion, the great contributions made by Dr. Clouston who, in his capacity as Adviser to the Government of India, has spared neither time nor energy to help them from time to time with his sound advice and mature experience. When I have singled him out for special mention I feel that I have conveyed my sense of appreciation of the services rendered by the entire cadre of which he is the acknowledged official head."

ORIGINAL ARTICLES

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, MR. J. T. EDWARDS; *Secretary for Publications*, MR. S. K. SEN).]

V. TICK-BORNE DISEASES, WITH SOME REMARKS ON THE DISEASES OF CATTLE CAUSED BY PROTOZOA.

BY

HUGH COOPER, M.R.C.V.S.,

Pathologist, Muktesar.

SYSTEMATIC examination of Indian cattle invariably reveals the presence of a number of parasites, frequently belonging to several different species, without any apparent ill effects being produced on the animals on which they occur, although in such cases the parasites are usually present in small numbers. On the other hand, under certain conditions, some of these parasites would appear to be capable of setting up severe and at times fatal complications. Evidence of the latter fact was obtained in the course of an investigation undertaken some time ago, at the Imperial Institute of Veterinary Research, relative to coccidiosis, a form of dysentery in cattle due to a protozoan parasite ot the intestine. Twelve calves apparently in normal health, and specially procured to serve as " clean " or uninfected animals, were subjected to detailed examination over a period of several weeks, during which time opportunity arose for *post-mortem* examination of several of them and in these no less than seventeen distinct species of parasite were detected, the more important of these from the disease-producing point ot view belonging to the protozoa. It was found, also, that the twelve calves already harboured small numbers of coccidia, and during the progress of the investigation one actually died of dysentery, under otherwise natural conditions, apparently due to the presence of these parasites, whilst another died of the disease when it had apparently almost completely recovered from an experimental attack of rinderpest. This is of interest as indicating the potential pathogenicity of certain groups of organisms normally living in a dormant state within the tissues of their hosts, since, when first obtained,

the calves showed no clinical indication of the infection, and the organisms could only be demonstrated by the application of a special method of concentration for their detection. Whilst furtherinvestigations are necessary to determine precisely the circumstances which allow a latent and usually harmless infection to assume the characteristics of a virulent and sometimes fatal disease, one understands in the case of rinderpest at least that a resuscitation of the dormant parasites may result from specific tissue depression following upon an acute, but not fatal, attack of the disease.

The same calves were also found to harbour two species of intracorpuscular protozoan blood parasites, namely, *Babesia* (=*Piroplasma*) *bigeminum* and *Theileria mutans*, these and similar other parasites being collectively designated by the name of "piroplasms."

B. bigeminum or the "large piroplasm" is the agent incriminated with the causation of acute or tropical "redwater" or the so-called "Texas fever" of America, and infection with this parasite is so widespread in India that probably in most localities cattle become infected as calves, at which age they possess a high degree of resistance, and are subsequently immune, by virtue of becoming "carriers" of the parasite in a latent state of activity for the rest of their natural lives. This immunity is, however, liable to become broken down, as in the case of coccidiosis, through the effects of intercurrent disease conditions, such as those following upon an attack of rinderpest, or through exposure to other adverse conditions, with the result that the animals may then succumb to "redwater" infection. The transmitting tick in India appears to be identical with that responsible for this disease in most other countries, such as the Southern States of United States of America and Queensland, namely, *Boophilus australis* (*Margaropus annulatus australis*). This tick is what is known as a "continuous" feeder, *i.e.*, it spends the whole of its life-cycle, from larva to ovigerous female, on one host, and this continuous period of attachment lasts 21 to 22 days.

With regard to *T. mutans* or the "small piroplasm," experience gained at Muktesar would seem to indicate that all cattle in India are infected with this organism, for careful examination of animals, at first supposed to be free from infection, invariably revealed the presence of these organisms, although the infection did not appear to be productive of any ill effects upon the host, even when the organisms occurred in large numbers. There is evidence on record, however, that under certain conditions the *mutans* parasite may be so exalted in virulence as to be capable of producing an affection similar to the formidable disease of Africa known as East Coast Fever, the causal agent of which is the protozoon *Theileria parva*. It is therefore not improbable that *T. parva* is in reality merely a virulent variant of *T. mutans* in the same way as the organisms of Malta fever of man and contagious abortion of cattle are now known to be very closely allied, and yet in pathogenic effects are different, and this hypothesis is further indicated by the fact that during the last two years at the Muktesar Institute, microscopic examination of

lesions found *post-mortem* in animals infected with *T. mutans* has revealed structures indistinguishable from those associated with the African disease. This kind of piroplasm is transmitted by ticks which, from the nature of their life-cycle, are what are known as " interrupted " feeders, *i.e.*, they " drop off " from their hosts between the larval and nymphal stages, and again between the nymphal and adult stages, on to the ground for varying periods of time during which they undergo a process of moulting, before they emerge into the succeeding stages, when they are again ready to climb on to a new host. The period of attachment to the host during the larval or nymphal stages varies from 3 to 6 days. The common " interrupted " feeder which occurs on cattle at Muktesar is the tick known as *Hyalomma œgyptium*, and it has been suspected in other parts of the world of transmitting infection of this kind.

In addition to the diseases enumerated above, there is evidence on record to indicate that certain ill-defined fevers may be induced by toxins or " poisons " injected by ticks at the site of puncture, whilst excessive parasitism may occasion serious mechanical injury to the host by setting up wounds which may become subsequently infected by maggots or lead to suppurating sores due to secondary infection by organisms ; or, again, the deleterious effects of tick infestation may be manifested in decreased milk production or in general loss of condition whereby the affected animal is rendered liable to contract other maladies.

The extent of economic advantages accruing from the maintenance of tick-free animals is strikingly illustrated by the fact that in one badly infected country it has been calculated that cows will yield at least one quart more milk daily and bullocks will increase in weight from 10 to 15 per cent., when freed from ticks, as compared with tick-infected animals.

In the early days of cattle breeding in Queensland, during the period following upon the natural disappearance of redwater in consequence of immunity acquired by the animals, the tick population increased to such an extent that unthriftiness of cattle during the tick season threatened to make cattle raising an economic failure, and the depreciation in value of hides due to injury inflicted by ticks was estimated at £114,000 for one year alone.

Fortunately, there has been, during recent years, an increasing realization of the importance of ticks not only as vectors of disease, but, as has been indicated above, as agents responsible for serious direct injury to live-stock, and the results of investigations carried out in other countries strikingly demonstrate the extent to which improvement in the condition of live-stock may be effected by the adoption of measures directed with the object of controlling this vermin.

It is now generally agreed that dipping of cattle in properly constructed " swim tanks " of adequate length, so as to ensure contact of the dipping fluid with the whole body surface for a sufficiently long time, is the only effective method of treatment for the destruction of ticks, since this object would obviously hardly be achieved with the same degree of thoroughness if such partial measures as spraying and

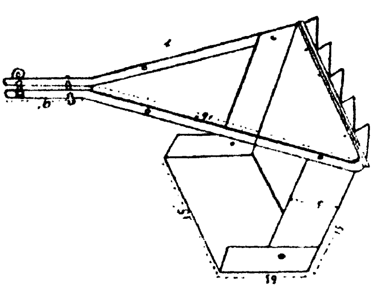
douching were resorted to. Attention has therefore been given in various countries to proper dip construction to ensure this effect, and several types of tanks of proved efficacy are now in use.

The frequency with which dipping operations have to be performed will obviously be determined with reference to the habits of the species of tick which it is sought to combat. Thus, in the case of a continuous feeder like the Texas Fever tick, dipping of cattle will have to be performed at intervals shorter than the period of attachment, and most authorities recommend dipping every 15 days for its eradication. On the other hand, in the case of interrupted feeders, such as those involved in the transmission of East Coast Fever, it would appear from what has been stated in regard to their feeding habits, that the interval between two successive dippings should not exceed 3 days, and in certain localities in Africa, where the cattle population has been threatened with extinction due to the existence of the menace of East Coast Fever, the institution of regular dipping at this interval of time has been enforced by law.

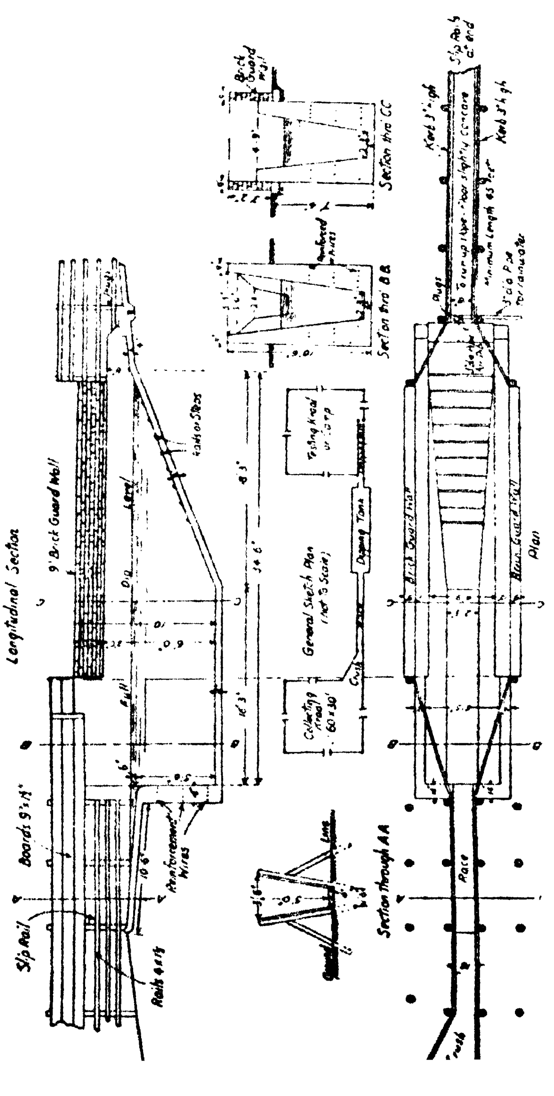
It has to be pointed out that, in order to make dipping effective for the purpose of combating redwater infection, it has to be performed over wide areas. Otherwise, it may happen that the dipped cattle are kept free from the piroplasm infection during their early age and are subsequently bitten by ticks that have become infected upon "carrier" cattle not subjected to the dipping treatment. (The infection is transmitted through the eggs of the ticks, from one generation to another.) In this way adult cattle may succumb to fatal redwater, owing to their having failed to secure immunity by passing through a mild attack of the disease during their early age. For this reason, where dipping has been practised for the eradication of redwater, as in the United States of America, it has been enforced wherever the transmitting tick occurs, by application of Federal laws governing the compulsory dipping of all cattle over areas covering many thousands of square miles, and quarantine regulations have not been withdrawn from any affected State until its cattle population have been certified as tick-free.

The dipping fluid almost exclusively in use is a solution of sodium arsenite made up to the requisite standard in accordance with one of the various formulæ recommended (*e.g.*, the formulæ for dipping fluid in use in Queensland).* In practice, attention is needed for the maintenance of the proper concentration and also the proportion of the ingredients, in order that the fluid, whilst exerting its maximum effect upon the parasites, may be harmless to the cattle undergoing dipping operations.

* There are several efficient official formulæ for arsenious cattle dips as used in Queensland, such as :—Queensland Cattle Dip 'A'—Arsenious acid 8 lb., caustic soda 4 lb., Stockholm tar ½ gal., tallow or oil (animal or vegetable) 4 lb., water 400 gal. ; Queensland Cattle Dip 'B'—Arsenious acid 8 lb., caustic soda 4 lb., bone oil 1 gal., water 400 gal. The recipe for what is known as the "Watkins-Pitchford Dip" is as follows :—Arsenite of soda 8½ lb., soft soap 5½ lb., paraffin 2 gal., water 400 gal. This dip has been used with success in combating ticks incriminated with the transmission of East Coast Fever.



Cattle Tank Dredger.



DRAWING OF DIPPING TANK.

(Reproduced from the Tropical Veterinary Bulletin, Vol. VII. No. 4.)

In view, however, of the costs involved in the institution of a system of regular dipping, the necessity of introducing such a system will obviously have to be determined with reference to the actual extent of loss suffered by a tick-infested locality.

The drawing of the type of dipping tank used in Rhodesia shown on p. 99 may be taken to serve as an indication of the dimensions, specifications and accessory requisites of a serviceable and economic dipping tank.*

*For further information on the important factors referred to above for carrying out effective dipping operations, *see* comprehensive extracts given in *Tropical Veterinary Bulletin*, Vols. 6, 7 and 8 (1918-1920). Details of methods of dipping are described by Knuth and Du Toit in *Handbuch der Tropenkrankheiten* (1921).

STUDIES IN SUGARCANE GERMINATION.

BY

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I. INTRODUCTION.

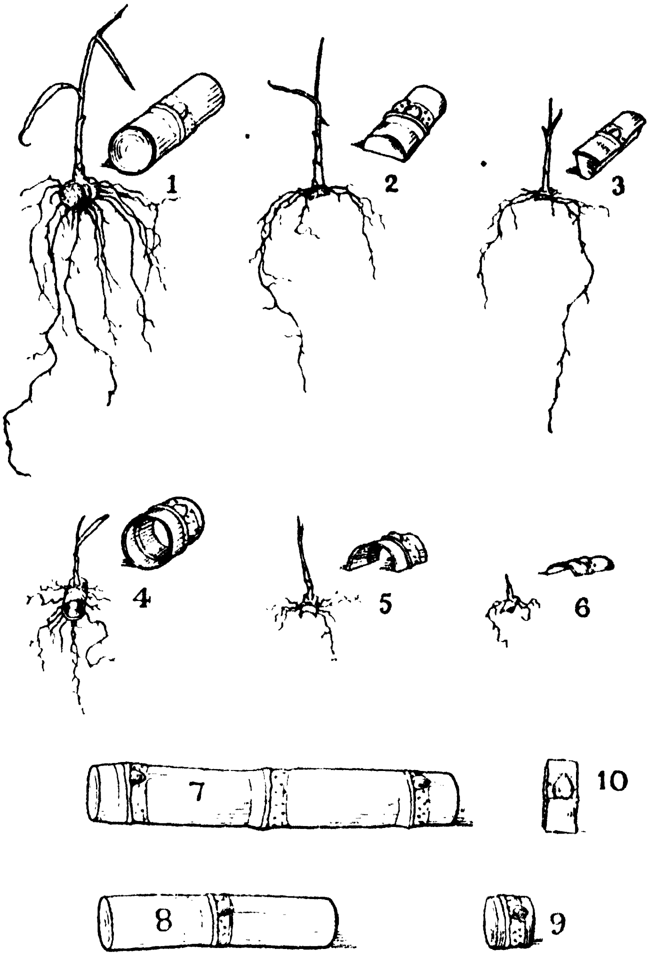
THE processes connected with the germination and early growth of the planted material is well worth a study in the case of any crop, because of adverse effects which a bad or weak germination often has on the crop at harvest. This is particularly so in the case of the sugarcane; in this crop plants which are poorly in the earlier stages or germinate later than others are often not able to catch the rest of the field in growth, sometimes even in spite of special treatment.

The subject has, therefore, been engaging some attention at the Coimbatore Sugarcane-breeding Station for the past three years as opportunities offered themselves. The results given below are thought to be of sufficient interest to warrant publication; some of the conclusions have a bearing on the preparation of planting material in sowing the sugarcane crop.

II. THE RÔLE OF THE INTERNODE IN GERMINATION AND EARLY GROWTH OF THE CANE PLANT.

In a sett at the time of germination the obvious centre of activity is the nodal region; both the buds and first set of roots have their origin in this portion. Secondly, in cutting up setts for planting, as is ordinarily practised by the cultivators, some variation is noticed in the amount of the internode that is allowed to remain at each end of the sett. Thirdly, in the case of planting material received from overseas, it was found that considerable portions of the internode—which had turned sour during transit—could be removed and yet healthy plants obtained from the material. The value of the internode in the germination and early growth of the cane plant, therefore, suggested itself as a fit subject for study. More than half a dozen series of experiments were laid during the last three years, and these gave similar results as to the value of the internode. Two of the experiments and one

set of observations recorded on the germination of a large number of varieties are detailed below.



Experiment I.

In May 1923, two varieties, B.3412 and Saretha, were sown, the planting material being suitably prepared to bring out in the resultant plants, differences if any from the presence or absence of the internodal portions. Sixty buds were sown in each experiment which was repeated three times in the plot. After a period of six months the entire growth including leaves was harvested and weighed. The experiments gave similar results and the results of one of them are given in Table I.

TABLE I.

Harvest results from sugarcane setts prepared in different ways.

Name of variety	Method of preparation of planting material	Weight of crop in lb. (six months from sowing)
B.3412	Ordinary three budded setts. (Fig. 7.) . . .	169
B.3412	Buds sown with the nodes, the internodal portions being removed. (Fig. 9.)	52
Saretha	Ordinary three budded setts	234
Saretha	Buds sown with the nodes, the internodal portions being removed.	170

Experiment II.

In March 1924, two varieties, B.3412 and Co.213, were sown, the planting material being treated in a different and perhaps a more efficient manner for the study. The experiment was repeated four times in the plot, twenty buds being used in each experiment. Table II gives the details of the methods of treatment and the results obtained.

TABLE II.

Harvest results from sugarcane setts prepared in different ways.

Name of variety	Method of preparation of planting material	Weight of crop in lb. (four months from sowing)
B.3412 .	Single budded setts with maximum internode on each side. (Fig. 8.)	42
B.3412 .	Single budded setts with minimum internode on each side. (Fig. 9.)	19
Co.213 .	Single budded setts with maximum internode on each side.	80
Co.213 .	Single budded setts with minimum internode on each side.	62

Experiment III.

The third set of results was obtained from observations on germination in the varietal plots at the station. In an ordinary three budded sett (Fig. 7) it is obvious that the central bud has available for its use a larger portion of the internode than either of the two end ones. If the internodes are of any use in germination, it was argued that the end buds might show differences either in the percentage of germinations or in the comparative weakness of the plants developing from them. Observations on the comparative germination of *end* and *central* buds were made on thirty-one varieties of Indian canes belonging to four different groups and forty-four Coimbatore seedlings. The table below gives the results.

TABLE III.

Comparative germinations of end *versus* central *buds in three budded setts.*

Variety	Number of buds studied	PERCENTAGE OF GERMINATIONS IN	
		Central buds	End buds
11 varieties of the Mungo group	660	64	28
7 varieties of the Saretha group	420	78	50
5 varieties of the Sunnabile group	300	68	32
6 varieties of the Pansahi group	360	63	44
44 Coimbatore seedlings	1,760	64	42

The above three sets of experiments show that the internodes have a distinct value in the germination and early growth of the cane plant.

III. THE RÔLE OF ROOT EYES AND PITH IN GERMINATION AND EARLY GROWTH.

After planting in the soil it is the nodal portions of the setts that show marked activity, one of the most noticeable features being the development of roots from the region of root eyes found at the base of every cane internode. Single budded setts with an inch of internode on either side were spliced longitudinally and portions of them planted in the soil to see the effect on germination. The experiment was further varied by removing the pith, leaving behind practically only the rind portions of the sett. The results are given in Table IV. The different methods of preparation of the planting material and the relative growths obtained from each of them on the seventeenth day are seen in Figs. 1 to 6 which are reproductions from photographs recorded at the time.

Table IV.

Germinations from single budded setts deprived of portions of the root zones and pith. Co. 210.

Method of preparation of planting material	Number of germinations on								
	5th	6th	7th	8th	9th	10th	11th	12th	13th day
1. Single budded setts with an inch of internode on each side (Fig. 1).	1	3	4	5	8	9	9	9	9
2. Single budded setts like (1) but spliced longitudinally into 2 equal halves, the half containing the bud being sown (Fig. 2).	..	1	1	3	5	6	7	7	7
3. Similar to (2) but the bud carrying only a quadrant of the sett (Fig. 3).	..	..	2	2	3	5	5	7	7
4. Similar to (1) but the pith removed (Fig. 4).	..	..	..	2	2	3	3	4	5
5. Similar to (2) but the pith removed (Fig. 5).	..	..	..	1	1	2	2	3	3
6. Similar to (3) but the pith removed (Fig. 6).	..	..	..	1	1	1	1	2	2

IV. The store of plant food in a planted sett.

The weakening in germination and growth with the loss of various portions of the cane sett as noticed in the above experiments, indicate that such portions are probably of use to the germinating cane plant as a store house of plant food.[1] In a set of experiments in which a dozen varieties were grown at the station in duplicate in two series of pots— one series filled with washed river sand and the other with the ordinary potting earth— it was found that the sand pot plants took six to eight weeks before they showed signs of starvation.

V. The irreducible minimum of the cane that has to be planted with the bud to ensure germination.

The experiments detailed in Section III were carried a step further, by carefully separating the buds alone from the canes and planting them for germination in small pots or glass chimneys filled with moist sand, blotting paper, saw dust, peat-moss and others. Thus treated the buds refused to germinate. The very few germinations that were obtained from these sowings were, afterwards, found traceable to a root eye or two which had escaped notice while preparing the material.

[1] Dr. H. A. Tempany has come to the conclusion that the storage of sucrose in the stem of the sugarcane is a definite provision for the propagation of the plant by means of shoots from the eyebuds *The Louisiana Planter*, 10th May, 1924).

So long as a root eye or two and the rind carrying them were included (Fig. 10), it was found that germinations could be obtained, though the resultant plants were rather poorly from lack of plant food.

The above results might be of some use in obtaining from diseased crops healthy planting material. For obtaining healthy material from diseased crops, it is obvious that the less of the diseased cane that is planted with the buds the greater the chances of securing a healthy stock. The method is likely to be of particular use in cases where the disease is confined to definite regions of the cane.

VI. Summary.

1. The internodal portion of a cane has a distinct use in the germination and early growth of the young cane plant.
2. The deprivation of root eyes and pith has a distinct adverse effect on germination and early growth.
3. The ordinary three budded cane sett contains enough plant food to keep the plant going for at least six weeks.
4. Sugarcane buds would germinate even when they are deprived of the bulk of the cane sett, so long as one healthy root eye with the rind carrying it, is attached to it at the time of sowing.

SHOULD AGRICULTURE BE ENCOURAGED?

BY

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THE most important problem demanding attention in India is that state to which some apply the term "poverty," while others prefer "a low standard of living." There are some who deplore it; others appear to be rather proud of it as a sign of a spiritual victory over materialism. In one of the most recent works on Indian economics, it is stated that "religion in India tends to keep both production and consumption within reasonable limits." With unusual boldness, the writer does not hesitate to say that "neither is the element of pleasure in consumption able to hypnotise him (the Hindu) into a modern believer in a high, very high, and yet ever rising standard of living, nor is his productive activity carried too far as an end in itself to produce commodities for the ever increasing wants, and thus never pushed to that point where it becomes a source of positive pain. That is why we find a peculiar atmosphere of serenity surrounding the Indian life, be it in the home, in the field, in the pasture, in the market or on the high road, nay, even in the courts and camps of our potentates. As each individual is born and grows to maturity, he finds his place in society, and has his standard of living, his standard of work and everything fixed. If an individual wishes to go beyond the standard of consumption of his class, and as a result becomes too much of an acquisitive person, both society and religion come down upon him, and by one and a thousand means succeed in getting a share of his superfluous possessions."[1]

In this description of the Hindu view of life, there is a large element of truth; if it were universally or even generally accepted throughout the sub-continent, there would be little hope for any permanent success in the efforts of the Agricultural Departments, Imperial and Provincial, and there would be less need for that expansion of activities which High Authority has foreshadowed.

There are, however, others who, while disapproving of Western materialism, are yet never weary of dwelling on the poverty of the Indian people, and their dependence on agriculture. There is a certain amount of "national" feeling in the demand for industrial expansion irrespective of the suitability of local conditions to large-scale manufactures on modern lines. It is hardly an exaggeration to state that not one of the "leaders of the people" recognize in agricultural improvement an adequate remedy for the prevailing low standard of living; their interest in this question has not been conspicuous. Indeed, some of the more extreme see in such improvements as American cotton but another example of the exploitation of India's resources in the interests of foreign capital.

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[1] Bhatnagar. *The Basis of Indian Economy* (1925), p. 54 ff.

If, however, it be permissible to hazard a guess at the opinion of the great inarticulate mass of the people, it may be suggested that it is to agriculture, and almost to agriculture alone, that they look and will continue to look for the satisfaction of their wants. In the Punjab, and probably elsewhere, there is a distinct tendency for the menial and artisan classes to take more and more to cultivation. It raises their social status ; and to the menials at least it seems to offer a means of escape from the lowly duties and the small rewards attached to their position. Even where men have ventured into factories and mines, they still continue their connection with agriculture ; industries in the present stage are yet a subsidiary occupation.

Among the more thinking members of the different communities, it is still agriculture which occupies first place in the list of methods for improving the economic position of the people. And High Authority supports them. India, they say, is predominantly an agricultural country, and agriculture should be encouraged. But are they right ? Should India be an agricultural country ? Will agriculture, even when improved by the laborious efforts, the enthusiasm, and the devotion of the experts, ever suffice to dispel poverty from the land ? Should agriculture be encouraged ?

Poverty may be regarded as the natural state of man, the state in which he is found when unaided by science, capital and enterprise. Without these, a low standard of living is inevitable, and even with these a low standard of living is his lot unless he is prepared to secure the fullest possible advantage from their use by hard and unremitting toil. The accepted conception of poverty, of course, is moulded by the standard of living prevailing in the particular locality. It is doubtful if the majority of the cultivating class regard themselves as "poor." In England that term would not be applied to men who owned as many acres of good land as large numbers of Punjab peasants do. But it may be taken as generally accepted that the people of India lack many amenities which should, if possible, be brought within their reach. For the purpose of the present argument it is unnecessary to enter into detail.

In the "Census of India, 1921," there is printed a table which has frequently been quoted and may be repeated yet again in the form below, showing the cultivated area per cultivator in the various provinces :—

Province	Cultivated area per cultivator acres
Bombay	12·15
Punjab	9·18
Central Provinces and Berar	8·48
Burma	5·65
Madras	4·91
Bengal	3·12
Bihar and Orissa	3·09
Assam	2·96
United Provinces	2·51

It is not intended to stress too much the importance of these crude arithmetical averages ; but for the purposes of this paper two points require attention : firstly,

the general low figure throughout the country, and secondly, the position of the Punjab as one of the most favourably situated provinces. In dealing below with details from this province, it must be borne in mind that other provinces are, if anything, in worse position. The figures given above include holdings of one acre and less, but the investigation made in the Punjab indicates that the omission of these does not make the remaining figures much more favourable, while many of these tiny holdings are in the hands of agriculturists by calling. Including these holdings, the average in Belgium is 5·7 acres, in France 15·05 acres, in Germany 19·25 and in England 26·95. On the continent of Europe, except in Belgium, the holdings are owned by the occupiers; in England and Scotland the occupiers are mostly tenants. The holdings in India are thus much smaller than are found in Europe. But in the latter, there are numerous holdings of the Indian size. Denmark is said to have 68,000 farms of less than 1½ acres, while three to four acres is common; France has over two million holdings under 2½ acres; Germany has over three million holdings with an average of a little more than an acre each; England has 81,000 holdings in the one-to-five-acre group. The tiny holding then is not confined to India, but is a common feature of nearly all countries; on the other hand, it would appear that these petty areas are not devoted to food-grains and field crops in the manner usual here.

It is now possible to enter into further detail of the size and distribution of holdings. From the results of an inquiry (published by the Standing Board of Economic Inquiry, Punjab : Rural Section), it appears that—

(*a*) about 17·9 per cent. of the owners of cultivated land in the province possess less than one acre of land; but the area thus owned is only one per cent. of the whole;

(*b*) about 40·4 per cent. of the owners own from one to less than five acres; the total area is about 11 per cent. of the whole;

(*c*) about 26·2 per cent. of the owners own from five to less than fifteen acres; the area involved being 26·6 per cent. of the land;

(*d*) about 15·5 per cent. own fifteen acres and over, comprising 61·3 per cent. of the whole land.

From the first table quoted, it will be clear that similar inquiries, if made in other provinces, would, with the exception of Bombay, disclose a still greater proportion of the smaller sized holdings.

A somewhat similar inquiry into the size of holdings cultivated per cultivator, which is about to be reported in another publication of the Standing Board of Economic Inquiry, indicates that in the Punjab over 22 per cent. of the cultivators cultivate one acre and less; 15·4 cultivate from one to 2½ acres; 17·7 from 2½ to 5 acres; 11·7 from 5 to 7½; and 9 per cent. from 7½ to 10. That is to say that 55 per cent. of the cultivators cultivate less than five acres.

Enough has been said to make it clear that the majority of the cultivators of India cultivate plots of under five acres, and that the under-2½-acre man is very

numerous. As it may be presumed that, as on the continent of Europe, family farming will continue to be the main feature of Indian rural activity, it may be stated that the real problem for India is to evolve a method of putting these tiny plots to such use as will enable a family to maintain a decent standard of living.

The Punjab figures make it plain that in that province at any rate there is ample scope for farming on broad-acre lines, provided that the owners of the over-fifteen-acre holdings will not split these up. Unfortunately, the evidence obtained by detailed village inquiries shows that most of these prefer to culsivate ten to twelve acres, and let out the rest on rent. Only about 8 per cent. of the cultivators cultivate more than twenty acres.

Mere area is an unsatisfactory test of a holding when the object is to discover what will prove sufficient to maintain a family in a standard of living which can be described as "satisfactory" or "decent." There are considerations to be weighed such as soil, means of irrigation, fragmentation or compactness, markets for the more valuable products, and so on. The term "economic holding" has little meaning without careful definition. In England, it is said that for market gardening and poultry an area of four acres is the minimum ; for dairying about 25 acres is required. The idea of a small holding as one of fifty acres is said to be out of date, and seventy acres is now regarded as "small." In Germany, the five-to-fifty-acre group represents the family farm ; in France, five acres under vine, or even less, will maintain and employ a family. In India an acre of tobacco will suffice. These very small holdings in Europe, however, are not given over to food-grains, but usually to commercial or industrial crops such as tobacco, hops, sugar-beet, flax, hemp, grapes, fruit, and vegetables. Moreover, even with these heavy-yielding crops, the cultivators, as said by Chapman, have to live hard, work hard and save hard. There is little room for that atmosphere of serenity which surrounds Indian life, if a family is to get anything approaching a decent livelihood from such tiny areas. Unfortunately also there is little hope that India will accept the methods and the crops which have been forced by economic pressure on the people of Europe. But it must be clear that unless some means can be evolved whereby families here can secure a decent livelihood from plots under five acres, and even under two-and-a-half, it is useless to look to the improvement of agriculture for a solution of the poverty problem. For the greater portion of the people, broad-acre agriculture offers nothing. For them something on market-gardening lines, petite culture, intensive production, must be evolved. The alternative is to pronounce the problem insoluble by the agricultural expert.

There can ensue no advantage from refusing to face the difficulty. Enormous areas of land may be put to more productive use by improvements and discoveries ; exports may increase, trade and commerce may derive great benefit, and the revenues of the country may mount up. The real problem facing the greater portion of the people will remain almost unaffected. It is the two-and-a-half-acre man and the five-acre man who need help. He is in the majority ; his case is the more pressing ;

if he remains unassisted, poverty continues unremedied. In his interests, should agriculture be encouraged ? Is there any prospect of rescuing him from his present state ?

To make the problem clearer, it may be useful to state the economic position of these people. It is true in a sense that the world lives by taking in each other's washing. Man produces in order that he may consume ; and he consumes either what he produces or what he gets in exchange for his produce. To him, it is of little importance whether he gets his food, etc., from his own fields or in exchange for the produce of his fields. Thus the area cultivated is important as affording opportunity for productive employment ; if the people could find subsidiary employment then the smallness of the holdings would matter less. The increase of wealth depends upon the margin between production and the consumption of the individual or family ; but the standard of living usually relates to consumption ; that standard is said to rise when the consumption of various articles and services increases and this requires an increase ot production of those articles. When dealing with people it is increase per head and not increase per acre that is important. If agricultural progress is to mean anything to the small man, it must improve the income from his small plot.

The small cultivators do not cultivate for profit. They get none. It is doubtful if they can be said to cultivate for a return on their labour. They cultivate for food. Discussions concerning costs of cultivation have little meaning for them. The margin of cultivation here is not decided by the labour expended so much as by the insistent demand for food from people to whom there appears no alternative but to sow the land in their immediate neighbourhood. Apart from food, the cultivator is apt to be satisfied with few amenities ; even where land is available he will not always cultivate more than he considers sufficient for his modest needs. Of the food produced, the greater part is consumed locally. The urban population being but a small fraction of the whole, its demands are met by but a small fraction of the total produced.

The geographical situation of India renders it impracticable to secure cheap supplies ot foodstuffs from overseas or from across its land frontiers. Distances enforce dependence upon local production. It is not economical to eat railway charges. The import of wheat from Australia a few years ago does not affect the general argument. The population of India is so great, its annual consumption is so immense, that it can neverbecome dependent upon external sources for its food. What is less generally recognized is that where there is no source of import, it is necessary to ensure a normal surplus so that a shortage in bad seasons will be met to some extent at least by the curtailment of this surplus. A normal surplus can only be encouraged by a ready market to absorb it, and this means the export of foodstuffs. This export is important firstly as a reserve against bad seasons, secondly as a means of paying for articles imported. The consumption of the latter constitutes one ot the elements in raising the standard of living. Apart from these

considerations, there is no object in cultivating foodstuffs for export, and care must be taken to avoid attaching too much weight to this trade.

It is sometimes urged that industrial expansion will render unnecessary the import of manufactured goods, and so there will be no need to export foodstuffs to pay for them, and the foodstuffs will then go to the towns. An expansion of industries is necessary to relieve the pressure of the cultivators and the waste of labour-power on the land, but the need to have a reserve against bad seasons will remain, and it will be a very dangerous condition for India if ever the country ceases to import commodities, for without import there can be no export.

In other countries, the existence of large towns, such as London or Paris, has exerted great influence on the agriculture of the surrounding villages, and similar effects are seen in India. The expansion of towns through industrial activity will serve to provide a better market for village produce, and will stimulate intensive cultivation ; but it is almost inconceivable that this expansion should proceed so far as to revolutionize the rural situation. At present, something like eighty to ninety per cent. of the people live in villages, and a doubling or a trebling of the urban population would hardly affect the problem of the petty cultivator. It is sometimes suggested that if all the manufactured articles now imported were to be made in India, the difference would be appreciable ; but the total amount of labour in various countries now employed on those articles represents such a small fraction of India's population that the withdrawal of this number from the villages would leave no appreciable effect.

Remembering, however, the connection between production and consumption, it is clear that the rise of the standard of living must be achieved through industrial expansion ; the amount of food, additional to the present scale, which the people could consume is strictly limited. Even allowing for an all-round improvement of diet, this would not suffice. Consumption must expand in other directions, clothes, houses, and the use of manufactured articles, and these must be produced somehow. It is doubtful if anyone would argue that the poverty problem can be solved if India should continue to export foodstuffs and receive manufactured articles in exchange. This would not relieve the position of the petty cultivator ; for him there will have to be industries ; some subsidiary to his cultivation, others attracting from the land the surplus labour which finds insufficient outlet at present. In order to reduce the immense number of these and raise the size of their tiny holdings, a large proportion must be attracted to other occupations.

The argument thus far is intended to call attention to the problem of that large section of the people who attempt to extract a living from tiny holdings. For them the chief end of agricultural activity is the production of food ; their case is such that it is the food and not any profit from its production which provides the stimulus to exertion and to the cultivation of inferior lands ; industrial expansion will enhance and not relieve this demand. Geographical factors must serve to restrict local consumption to local production, and in consequence local production is determined

by what the local people will consume. Of the foodstuffs produced in any area, the greater portion is consumed within that area. The export trade hardly affects the cultivator of tiny plots, and the volume involved represents but a small fraction of the total produced. It may be stated in brief that, under present conditions, there are too many people employed for too short a part of their time in extracting too little produce from too large an area. If this be accepted then the question whether agriculture should be encouraged in the interests of these small cultivators resolves itself into the problem whether they can be taught to grow more food on smaller areas so as to relieve the rest for commercial crops for sale in exchange for other commodities. If a greater intensity of cultivation is to be encouraged, then the crops should be such as will respond to the extra labour. Thus the problem in large measure becomes one of the diet of the people.

If the present diet does not permit of sufficient scope for more intensive and more scientific cultivation, it must be changed. The process is already observable in the increasing consumption of potatoes, fruit and vegetables. The greater attention to agriculture which High Authority foreshadows, must be devoted to intensive production of fruit and vegetables, to the problem of diminishing the area under food crops so as to relieve more for money crops, which means the production of more food per acre. That it may be necessary to aim at an extensive alteration of the diet of the people must be freely recognized. Without this, it is doubtful if much can be done.

The cultivation of field crops is largely a matter for the cultivator of bigger areas; by itself it will not assist much the petty holder who forms over half the total. The agricultural expert can point to the large area available in the bigger holdings, and there is no question that improvements on the lines already followed with such success will add to the wealth of the country, will increase trade and public revenues, and enhance the national income; but the object of this paper is to draw attention to the case of that large section of the people for whom only highly intensive cultivation will suffice.

It seems very necessary when discussing an expansion of the Agricultural Departments to recognize the distinct difference between the classes which cultivate for profit, and those which cultivate for food. Either this new interest of High Authority is to mean nothing to the greater portion of the cultivators of India, or it is to mean something tangible, some hope of a definite improvement in their economic position, some practical advantage to be reaped in their homes. The Agricultural Departments are not primarily concerned with prospects of industrial expansion, although such expansion may profoundly affect their policy, just as it may affect cropping. Whether they are concerned with the lot of the petty cultivators may be open to question. If they are, then some at least of the increased activity now foreshadowed should be directed towards the problem of finding efficient employment of the family labour on these millions of tiny plots, a problem which is largely bound up with the diet of the people.

The argument can be summed up somewhat as follows : of the total cultivated area of British India, about 84 per cent. is devoted to food crops, about 75 per cent. is devoted to food crops for the people of the country, ten per cent. being exported ; about 60 per cent. is devoted to feeding the people of the village where the crops are grown, the rest going to the towns. The problem has a twofold aspect : first to grow the food of the people on a smaller area so as to release a larger area whereon to grow money crops, and secondly to discover such food crops as the people will consume and as will respond to intensive cultivation, so that the family may be more fully occupied on the tiny holding with profit to themselves. In brief, it is extremely important to devise a scheme whereby the cultivators will be able to use their present leisure in the profitable cultivation of their holdings. It is doubtful whether any scheme could be evolved to occupy all the present leisure, so that the need for subsidiary industries will remain, but this is outside the scope of the present paper.

ON THE USE OF MANURE AS FUEL.

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The practice of converting dung in dung cakes for fuel purposes is very common in the Punjab and probably throughout India, and very little attention has been paid to the enormous manurial loss to the country which is incurred thereby.

Whereas in intensively cultivated countries of Europe, a large expenditure on artificial manures is necessary to obtain the maximum return from up-to-date scientific agriculture, the soils of India have not reached such a condition as would compel serious attention to the question of their deterioration, nor has attention been focussed to any degree on the practical benefits which would accrue to the soil, the zemindar and the community in general if all the manure which is burnt could be applied to the soil, thus increasing both its "manurial content" and its general "condition" owing to the great "physical" value of manure. It is proposed in this article to trace the causes which involve this heavy loss every year, and to present some statistical information, both from theoretical and practical points of view, which will show that the practice of burning farmyard manure is uneconomic and destructive.

The following appear to be some of the chief causes responsible for the loss incurred by the practice of burning manure.

(1) Want of a readily available substitute for dung cakes which can be used for fuel purposes.

The wasteful economy of burning manure as fuel is recognized by good farmers, but its discontinuance obviously depends on the facilities for obtaining a cheap fuel in sufficient quantities.

The question of the supply of cheap fuel to the zemindars has not so far, however, been seriously considered either by the zemindars themselves or by Government, and from the data presented herein showing the loss involved, it is evident that the material which represents such a large amount of capital should be most carefully conserved, and the problem of supplying an adequate fuel supply is one which should be most seriously considered in all future schemes of colonization. The supply of

wood for fuel, therefore, constitutes one of the important factors to be taken account of, in indirectly maintaining the fertility of the soil and the prosperity of agriculture.

FIG. 1. Heaps of dung cakes in a village in the Lyallpur Colony.

(2) The careless manner in which manure is collected and stored, results in a manure of poor quality, which is partly responsible for the zemindar not getting the full benefits which he would otherwise do by using a good manure obtained by proper storing. The manure heaps are generally exposed and are unprotected with the result that the most valuable constituents are lost.

It is not the object of this paper to deal at any length with the methods for the proper collection and preservation of farmyard manure, but a glance at Table I

TABLE I.

Wheat experiment, Rothamsted, 10 tons (per acre) of stored manure applied.

	Control	1	2	3	4
Crop yield, total produce, lb. per acre	4,948	5,792	5,649	5,364	5,185
Percentage increase	..	17	14	9	5
History of manure, bullock dung stored for 9 months.	..	Compact under cover.	Loose under cover.	Compact in the open.	Loose in the open.
Percentage composition of manure—Dry matter	..	21·4	26·0	19·5	24·5
Total nitrogen	..	0·523	0·674	0·474	0·580
Nitrogen as NH_3	..	0·040	0·015	0·007	0·012
Nitrogen as amide	..	0·044	0·058	0·039	0·051
Nitrogen as other compounds	..	0·439	0·601	0·428	0·517

which shows results obtained by Russell and Richards[1] by the use of manure prepared in different ways, will reveal the fact that the best yield is obtained by heaps

[1] Russell, E. J., and Richards, E. H. The changes taking place during the storage of farmyard manure. *Jour. Agri. Sc.*, VIII, pp. 495-563.

which are compact and are under cover. Whereas the ordinary farmyard manure gave a yield 5 per cent. greater than the control, the stored manure gave as much as 17 per cent. above control.

The results of seven years' trials at the Burdwan farm [1] on potatoes showed an average yield per acre of 9,789 lb. with 600 mds. of farmyard manure stored at the farm by improved methods, against a yield of 8,490 lb. with a similar quantity of manure purchased from the ryots. Also experiments carried on by the Central Provinces Department of Agriculture showed that ordinary village manure contained on an average 0·46 per cent. of nitrogen, while cattle manure properly stored on Government farms in the province contained 0·68 per cent.[2]

(3) On account of new irrigation projects which have been, and are being taken up in the Punjab, huge areas of fertile lands are being brought under cultivation, and many agriculturists have moved from old tracts towards the colonies and are able to handle bigger areas than they formerly used to, with larger profits.

This is perhaps partly responsible for the lack of attention (necessity not yet being felt) to intensive farming where the need for quick acting manures is felt. Time will come when no new lands remain to be settled, and with an increasing demand for a greater supply of foodstuffs, a more intensive farming will become necessary. It would be unwise however to ignore the question of preserving all the manurial material we can for the soil till these times come, and attention should be focussed now on reaping larger profits from the land by serious attention to the manure problem.

(4) Minor causes such as inherent carelessness on the part of the zemindars in improving upon their old methods and a lack of proper education and training in the practice of agriculture are by no means less important.

In the following paragraphs an effort has been made to calculate the loss to the province due to the burning of dung as fuel.

In Table II are presented the analysis of an average sample of dung cakes, and average figures for the analysis of farmyard manure.

TABLE II.

Analyses of dung cakes and farmyard manure.

	Average analysis of farmyard manure	Average sample of dung cakes
Moisture	60·0	3·68
Ash	25·2	41·36
Total nitrogen	0·50	0·81
Potash as K_2O	0·67	0·93
Phosphoric acid as P_2O_5	0·28	0·485

[1] *The Indian Agri.*, XXIX, p. 318.

[2] Clouston, D. Manures in their relation to soils and crop production in the Central Provinces. *Agri. Jour. India*, XIV, pp. 101-106.

In Table III the prices of the manurial constituents in dung cakes and farmyard manure are calculated on the basis of the current prices of artificial manures.

TABLE III.

Manures	Prices of manures		Price per lb. of manurial ingredient
	Analyses	Price per ton	
		Rs.	
Sodium nitrate	15% nitrogen .	245	11·7 annas per lb. of nitrogen.
Superphosphate	18% P_2O_5 .	100	4 annas per lb. of P_2O_5.
Potassium sulphate	25% K_2O .	200	6 annas per lb. of K_2O.

One ton of dung cakes contains

	Rs.	A.	P.
18·14 lb. of nitrogen	13	4	0
10·86 lb. of P_2O_5	2	11	0
20·83 lb. of K_2O	7	13	0
TOTAL .	23	12	0

and

One ton of farmyard manure contains

	Rs.	A.	P.
11·2 lb of nitrogen	8	3	0
6·27 lb. of P_2O_5	1	9	0
15 lb. of K_2O	5	10	0
TOTAL .	15	6	0

It will be seen that a ton of cakes calculated on this basis should have a value of Rs. 23-12, while farmyard manure should be valued at over Rs. 15-6 a ton. In actual practice, however, in the village farmyard manure never sells for more than Re. 1 per ton, whereas dung cakes fetch a price of Rs. 6 to Rs. 7 per ton in villages and from Rs. 8 to Rs. 9 per ton in towns for fuel purposes.

These figures do not take into consideration the particular value of manure (apart from manurial ingredients) as represented by the humus content or organic material which is so valuable in both improving the physical texture of the soil, and in liberating organic acids which in turn render more plant food available.

Some idea of the value of this humus may be obtained by reference to Table IV (Table XII of Bulletin 149 (published by the writers) of the Pusa Institute). It

TABLE IV.

Showing the economics of the trials on irrigated tracts at Lyallpur where green manure is carted from elsewhere.

Treatment	Increase of yields over controls per acre								Total increase		Value of the produce		Total value	Cost of digging in the green manure per acre	Profit per acre	Remarks
	1918-19		1919-20		1920-21		1921-22									
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw				
	M. S.	M. S.	M. S.	M.S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	Rs. A.	Rs. A.	R. A.	Rs.	Rs. A.	
1. *Guar* 1 crop, 240 mds. per acre.	4 33	7 15	8 27	21 10	2 30	10 10	0 15	4 10	16 25	43 5	99 12	32 0	131 12	108	23 12	Green manure was dug in twice, *i.e.*, both before sowing wheat in 1918 and 1919.
2. *Guar* 2 crop, 480 mds. per acre.	10 8	13 35	16 6	43 20	8 10	18 20	5 0	13 15	39 24	89 10	237 8	66 12	304 4	200	104 4	
3. *Guar* 3 crop, 720 mds. per acre.	12 38	24 25	14 1	50 30	14 20	27 10	5 0	14 35	46 19	117 20	279 0	88 0	367 0	300	67 0	

NOTE 1.—Cost of digging in the green manure per acre, crop Rs. 40, cartage Rs. 3, ploughing in Rs. 5, cutting Rs. 4; miscellaneous Rs. 2, total Rs. 54 per acre.
NOTE 2.—Wheat grain selling at Rs. 6 per maund straw selling at As. 12 per maund.

is supposed that the increase of yield is almost entirely due to the beneficial action of the organic matter contained in the green manure.

In all, 2,880 maunds of green *guar* (*Cyamopsis psoralioides*) were ploughed in these plots. This represents 518·4 maunds of dry *guar* containing 11·45 per cent. of ash, or in other words the 2,880 maunds of green *guar* contain 459 maunds of organic matter.

The total gain due to the addition of the *guar* was equal to Rs. 195, and hence one maund of organic matter was responsible for producing such increase of yield as is represented by annas six pies nine.

Now one ton of dung cakes contains 15·4 mds. of organic matter, and calculating theoretically on a similar basis, this will have a value as represented by an increased production of Rs. 6-8.

Hence adding the value of the manurial ingredients as such, together with the increased yield produced by virtue of the organic matter contained, the actual value of one ton of dung cakes thus theoretically calculated should be Rs. 30-4.

Assuming that in the process of burning dung cakes practically the whole of the nitrogen is lost[1] and say half the phosphoric acid is not immediately available on account of fusion, the net loss per ton works out at Rs. 21-2. It will be contended that comparisons are being made between dung cakes where the manurial constituents are not in the available form and the most quick acting artificial manures, and this is admitted, but it is assumed that the dung cakes will be applied in the form of well-rotten farmyard manure which for rapidity of action compares favourably with artificial manures.

These calculations may appear to the reader to be too theoretical, but the values are based on concrete facts and analytical results, and it is perhaps justifiable to represent these facts on a monetary basis, and there would appear to be no logical reason why the value of farmyard manure should not so be calculated.

A method is given below by which prices can be calculated in a more practical manner.

By referring to experiments[2] conducted by the Professor of Agriculture in Square 27, Manurial Block, at the Lyallpur Agricultural Experimental Station, we note the various increases in crop yields due to the addition of 5 tons farmyard manure per acre over controls. For convenience a summary of these statements is given in Table V, and the average increase in the case of each crop is represented graphically

[1] Clouston, D. Manures in their relation to soils and crop production in Central Provinces. *Agri. Jour. India*, XIV. p. 102.

[2] *Annual Experiment Record (Department of Agriculture, Punjab)*, for the year ending 30th June, 1919, pp 11 and 12; 1920, pp. 29 and 30; 1921, p. 94; 1922, pp. 149 and 180; and 1923, Vol. II, p. 67

TABLE V.

The yields of crops by the use of farmyard manure compared with those on untreated plots.

Crop	Treatment: Farmyard manure at 5 tons per acre	Treatment: Control	Increase over control	Value of increase over control	Total value of increased yield	Total quantity of manure used	Increase due to one ton of farmyard manure	
	Mds. Srs.	Mds. Srs.	Mds. Srs.	Rs. A. P.	Rs. A. P.	Tons	Rs. A. P.	
I Series—								
Maize	21 25	17 20	4 5	12 6 0	250 14 3	30	8 5 0	If 20 per cent. profit is allowed on the money invested in the use of farmyard manure, the price of farmyard manure should be Rs. 6-15 or, say, Rs. 7 per ton.
Barley	13 20	7 27	5 33	17 7 0	..	..	..	
Cotton	6 21	4 15	2 6	43 0 0	..	..	..	
II Series—								
Maize	* 22 1	* 19 13	2 28	8 1 6	..	..	..	
Wheat	18 25	7 36	10 29 }	73 10 0 }	..	..	..	
			Bhusa 19 27 }	14 12 0 }				
Cotton	2 6	1 36	0 10	5 0 0	..	..	..	
III Series—								
Maize	22 16	21 7	1 9	3 11 0	..	.	..	
Wheat	15 22	8 36	6 26 }	33 4 0 }	..	..	..	
			Bhusa 16 9 }	12 3 0 }				
Cotton	14 23	12 8	2 15	47 8 0	..	..	..	

	Mds. Srs.	Rate per maund.	Total value of increased yield.
		Rs. A. P.	Rs. A. P.
Average increase over control in the case of—			
Maize	2 27	3 0 0	8 0 0
Wheat (Grain)	8 28	5 0 0	43 8 0
(Straw)	17 38	0 12 0	13 7 6
Barley	5 33	3 0 0	17 8 0
Cotton	1 24	20 0 0	32 0 0

* Average of yields from Series I and III.

in Fig. 2. This table indicates that during three rounds of the rotation 30 tons of farmyard manure were used costing Rs. 45, and the net value of the increased yields due to the application of this manure was Rs. 250, showing a net profit of Rs. 205.

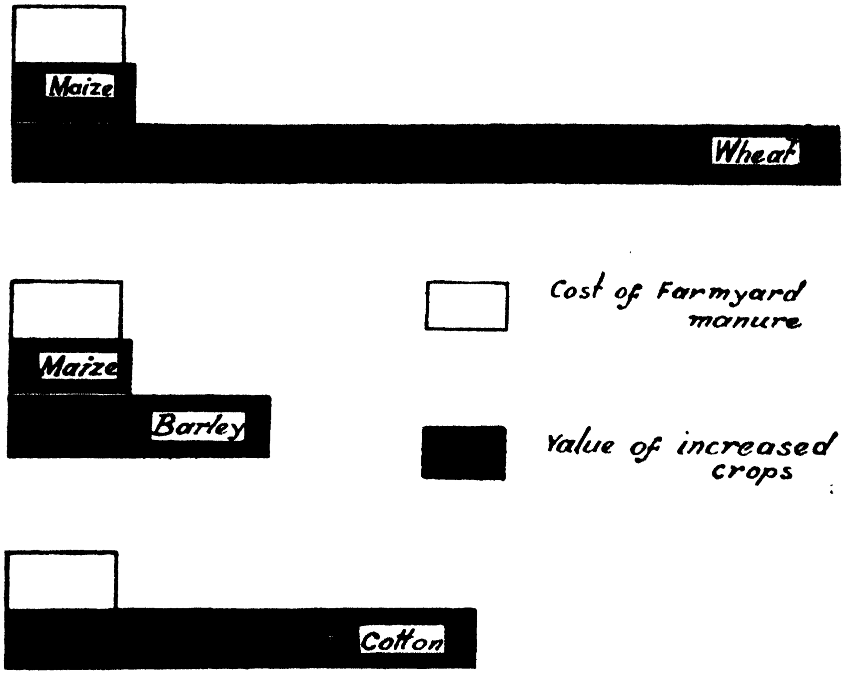

FIG. 2. Diagram showing cost of farmyard manure and value of increased crops over controls.

If 20 per cent. profit is allowed on the money spent for the purchase of farmyard manure, the price of farmyard manure should be Rs. 6-15 or, say, Rs. 7 per ton.

Two other factors however have to be considered.

(*a*) No account has been taken in these calculations of the continued residual effect of the manure, which effect would continue to produce an increased yield; and

(*b*) five tons farmyard manure per acre is perhaps not the optimum quantity to apply, a greater application might produce a still greater excess yield over control, when the figure of Rs. 7 per ton already calculated would be higher still.

From data given below it can be calculated that each ton of dung cake if utilized as farmyard manure in the beginning would have represented 2·5 tons of manure, owing to the cakes containing proportionally less moisture.

Therefore, a ton of dung cakes, calculating on the above basis, represents a loss of Rs. 17-8.

From enquiries made it has been found that on an average 50 per cent. of the dung produced in villages is converted into dung cakes by the zemindars, except of course in places where wood is abundant and cheap.

According to the quinquennial census of cattle taken in 1922, there are the following numbers of cattle in the Punjab :—

Bulls	12,468
Bullocks	4,138,490
Cows	2,740,925
Buffaloes (male)	441,743
Buffaloes (Female)	2,641,249
TOTAL	9,974,875
There are also 5,120,420 young stock, and if we assume that four young animals produce the same quantity of dung as one *adult*, we have to *add*	1,280,105
making a grand total of	11,254,980

In the Kangra, Simla, and half of the Rawalpindi Districts, fuel is both cheap and abundant and most of the dung is returned to the soil. Therefore deducting the number of cattle of these districts, *viz.*, 624,453, from the total, we get a final total of 10,630,527 to be considered. On an average it is estimated that an adult animal produces 30 lb. of fresh dung daily, giving a total daily production of 142,373 tons. If ⅔rd of this is delivered in the stall, say 94,916 tons, and 50 per cent. of this is converted into dung cakes, the cakes represent 47,458 tons. As farmyard manure contains about 60 per cent. moisture and fresh dung about 75 per cent., 47,458 tons of dung would produce 29,661 tons of farmyard manure, or a yearly production of 10,825,900 tons representing about 1·5 crores of rupees at the market rate of Rs. 1-8 per ton, or about Rs. 7·6 crores if we calculate according to the data in Table V, and a still greater figure if we base our calculations on the manurial values as represented by chemical analysis.

It is universally recognized that no artificial manure or a combination of several has succeeded in keeping up the fertility of the soil so well as farmyard manure. This is mainly because, in using artificial manures, we supply the end products to the plant instead of waiting for them to be liberated gradually by natural decomposition. Farmyard manure and also the plant residues (which are essentially the same thing) decompose in the soil, giving rise to many substances of different types. In fact, we do not by any means know the whole of the processes whereby plant food is made. But there are certain intermediate products, and it is quite possible that some of these may have special effect on the growing plant, somewhat comparable with that of the vitamins of plant physiologists. It will be interesting to mention here for the information of those who are interested in the prosperity of the Indian farmer that people in more advanced countries practising a more intensive cultivation, having fully realized the benefits of farmyard manure, have begun researches on the manufacture of artificial farmyard manure, without the agency of live-stock.[1]

[1] *Int. Rev. of Sci. and Prac. of Agri.*, N. S., Vol. II, No. 1.

Conclusion.

Three methods of calculating the loss to the province of the Punjab through the practice of burning dung have been investigated :

(1) Based on the actual market value of farmyard manure showing a loss of 1·5 crores.

(2) Based on the value of the manure at Rs. 7 a ton calculated from the increased yield over controls, allowing for a 20 per cent. interest, also showing a loss of about 8 crores.

(3) Based on manurial values as represented by chemical analysis.

Even considering (1) alone, the picture drawn is sufficiently convincing to indicate that every endeavour should be made to tackle the problem of the conservation of this valuable plant food for the future.

CAUSES OF INFERTILITY IN SOILS IN RELATION TO BACTERIAL ACTION.*

BY

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INFERTILITY as a negative term suggests the absence of elements required for fertility; it is necessary, however, to realize that infertility may result from the presence of substances or conditions inimical to the growth of plants.

The causes of infertility in soils may, therefore, be divided into two main groups or classes :—

(1) Those associated with the absence of substances or conditions necessary for fertility.

(2) Those depending for their action upon the presence of deleterious substances or conditions liable to interfere with the growth of plants.

To the layman an infertile soil suggests either a desert tract entirely bare of vegetation, or perhaps an area at one time under cultivation but now abandoned because of its infertility. The agriculturist, however, has a much higher standard of fertility in mind; to him an infertile soil is one which it does not pay to cultivate or at the best is of such poor quality or condition that nothing but necessity would make him spend his time and labour in doing so. To this latter class belongs a large proportion of the arable lands now under cultivation; these have come down from their original condition of high fertility as virgin soils to their present state of comparative infertility as a direct result of the artificial conditions of plant growth to which they have been subjected during years of crop cultivation. It is with this class of soils requiring highly expert treatment and knowledge that we are mainly concerned, those in which the degree of fertility is so low that relatively small causes, or infertility factors, may at any moment reduce their yield below the point at which it ceases to pay to cultivate them. It is therefore of prime importance for the agriculturist to be well acquainted with the various and numerous causes of infertility which may reduce the condition of his soil and the amount of his crop below the paying minimum.

One of the most common and well understood causes of infertility is the lack of a sufficient supply of those ingredients in the soil which are necessary for fertility. It is impracticable here to deal with these except to point out that an insufficiency

* Lecture delivered to the Pusa Scientific Association on 22nd December, 1925.

of plant foods not only affects the growth of crops directly but also indirectly by limiting the activities of those bacteria upon which fertility depends. This is more especially the case with reference to the supply of humus, for reasons to be dealt with later.

Water supply of course is a vital factor and must be taken account of both from the point of view of deficiency and of excess ; this implies management of the soil in such a way as to avoid both deficiency or excess of water, the latter with its concomitant result of lack of air being especially conducive to infertility by reason of its effect on bacterial activities in the soil.

On the other hand, infertility may result from the presence of harmful substances in the soil such as excess of organic acids or of alkali salts and in some cases of neutral salts including chlorides, sulphates and nitrates. With these causes of infertility we are not for the moment concerned, but others more generally distributed exist which are of great importance although perhaps not fully recognized as such. Under certain conditions toxic bodies are produced in soils and their influence upon fertility depends largely upon the quantities in which they are present. Generally speaking, their production depends upon the existence of anaerobic conditions due to waterlogging and is the result of bacterial action of the class associated with this condition. In order to understand not only how such bacterial action takes place but to arrive at an adequate conception of its importance as a factor in soil infertility, it is necessary to know something about that class of soil organisms known as anaerobic bacteria. There is no definite dividing line between aerobes and anaerobes, that is between such bacteria as require oxygen and those that do not; there is an intermediate class the members of which can tolerate varying degrees of aeration or the reverse and even those species which are apparently obligate anaerobes can function in presence of small amounts of oxygen, especially in conjunction with certain aerobic species whose activities reduce the oxygen tension in the soil water. The fact that it is necessary to bear in mind is that soil conditions, so far as anaerobism or the reverse is concerned, determine whether anaerobic or aerobic bacteria shall predominate in such soils with results which will vary in accordance with the characteristic differences of their action.

Anaerobic bacteria and anaerobic fermentations are generally associated with unhealthy conditions of one kind or another ; thus putrefaction as opposed to decay is produced mainly by anaerobes, which are also responsible for most septic conditions and incidentally for tetanus.

Anaerobic bacteria in soils produce infertility in several ways :—

(1) By the production of colloidal bodies resulting from decomposition of organic matter, plant residues, roots and stubble, dead leaves, green manures, oilcakes and cattle manure. These colloidal bodies take the form of bacterial waxes or slimes which coat the surfaces of the soil particles and tend to block up the pores of the soil, thus interfering with aeration and drainage. It is of interest to note that the

coating of the soil particles both organic and inorganic with bacterial wax has the effect of protecting them from further bacterial action, thus reducing the rate and amount of such important processes as nitrification of organic matter and solubilization of mineral phosphates. The fertilizing action of such partial sterilizing agents as toluene can be partly attributed to their solvent action upon this coating, exposing fresh surfaces to bacterial action; a similar result is produced by the mechanical rubbing and grinding action of cultivation processes such as ploughing and harrowing, and also by the aeration and desiccation resulting from the latter which tends to destroy the colloidal condition of the bacterial slimes. It is important to realize that anaerobism in soils tends to increase by reason of the fact that the anaerobic classes of bacteria, whose growth and preponderance results from the prevalence of this condition, are themselves capable of contributing to and increasing it by the production of colloids; thus the vicious circle is completed and this tendency becomes of great practical importance.

(2) By the production of toxic bodies which reduce fertility either (*a*) directly as plant poisons, or (*b*) indirectly by their interference with nitrification.

The first case involves exceptional conditions such as waterlogging, or a soil of naturally high non-porosity such as a heavy clay.

Waterlogging in the presence of organic matter results in the production not only of colloids but of plant poisons by anaerobic bacteria. The presence and action of such poisons can be demonstrated by watering plants with extracts of anaerobically incubated soils, apart from the well known effects of attempting to grow plants in soils in which drainage has been interfered with or in which anaerobic fermentation of organic matter has been carried out to excess.

The maize plant affords an interesting case of natural provision against poisoning by organic toxins resulting from soil anaerobism; the secondary aerial root system commonly found in this plant is a provision against the absorption of toxins resulting from anaerobic conditions due to excess of moisture in the subsoil, which the plant is able to avoid by putting out secondary roots into the surface soil at that period of its growth when flooding of the soil is liable to occur.

Intoxication of the seedling maize plant is also liable to occur in wet soils as a consequence of bacterial invasion of the seed whilst the latter is still attached to and is providing nutriment to the young plant. This form of damage is probably due to mechanical injury to the seed-coat generally as a result of insect attack.

A special case of anaerobism is that produced by the growth of grasses, the closely interwoven roots and stoloniferous stems forming a sod or layer not only relatively impervious but giving rise to extra quantities of CO_2 in the surface soil by their decay. There is reason to believe that under certain conditions especially in

wet seasons, toxins are formed as a result of the decay of parts of this growth ; this result may be noticed where cut grass from the mower is allowed to lie during wet weather on the surface of turf, which is completely killed by this treatment and may not recover for months afterwards. In addition, the partially anaerobic conditions induced in the soil interfere with nitrification and consequently reduce fertility ; this effect may be observed and measured and is probably responsible for the very marked and well known inhibitory action of grass upon the growth of trees.

Indirect action of toxins on fertility.

Nitrifying bacteria are known to be highly susceptible to the action of toxins of various kinds. Soil sterilized by heat is not only lacking in nitrifying organisms but when these are reintroduced by inoculation their normal action is inhibited by toxic bodies produced by the action of heat upon the organic matter present. Similarly anaerobic incubation of soil results in the production of toxins having an inhibitory effect upon nitrification, and in addition cases have been observed where anaerobic conditions in a soil have resulted in the multiplication of specific bacteria, capable of inhibiting nitrification by the toxic action upon the nitrifiers of the bye-products of their metabolism. This action is most pronounced in presence of organic matter, which will fail to nitrify in a soil under reduced air supply, whereas the same soil under similar conditions of aeration will nitrify ammonium sulphate. That this inhibition of nitrification is due to the production of toxins from the organic matter is shown by the fact that nitrification does not immediately take place in a soil treated in this manner when complete aeration is provided subsequently, but only commences after a period of time (some ten to fourteen days) sufficient to allow of destruction by oxidation of the toxins thus formed.

In this case therefore we have an instance of infertility caused by interference with nitrification and resulting from the action of toxins not present in sufficient amount to produce directly harmful action on plants. The importance of recognizing this source of infertility lies in the frequency of the occurrence of the conditions giving rise to it. Any condition of the soil causing any degree of anaerobism will encourage the growth of those classes of bacteria responsible for the effects described above ; such conditions may arise from improper soil management, such as ploughing when too wet, or from physical properties of the soil itself rendering it peculiarly liable to this source of infertility.

Relation of the above facts to agricultural operations.

Agricultural operations consist mainly of :—

(1) Cultivation, *i.e.*, stirring the soil.

(2) Irrigation or drainage, *i.e.*, controlling the water supply and with it the air content

(3) **Manuring—the addition of plant food in a suitable form.**

(4) **Selection of suitable crops and of improved varieties to make the most of natural fertility or to minimize the effects of natural infertility.**

Cultivation. The principal function of cultivation is to regulate the water supply of the soil and promote formation of available, *i.e.*, soluble plant food, especially nitrates. Nitrification depends upon a suitable balance between air and water supply and upon removal or oxidation of certain byeproducts of bacterial metabolism ; if this is not provided for, either nitrification does not proceed at a sufficient rate or the reverse action, *i.e.*, reduction of nitrates by bacterial action occurs, the bacterial balance being then against the accumulation of nitrates sufficient for fertility. Therefore the operations of ploughing, harrowing, rolling and inter-cultivation must be carried out with a view to maintaining in the soil such conditions of water supply and aeration as will promote nitrification at that time of year when the growing crop is ready to absorb it. Hot weather cultivation has other functions besides that of killing out weeds ; this operation has a very decided action in lowering the percentage of anaerobic bacteria, destroying many of the deleterious byeproducts of their growth, including some colloids, by oxidation and desiccation, and probably strongly discouraging certain infective and pathogenic organisms such as *Ps. tritici* and *Bact. solanacearum.* Ploughing wet has an extremely bad effect on many soils ; the result is infertility due mainly to destruction of the mechanical condition or tilth, this is brought about largely by the operation of a most important factor in soil physics, namely the film of air which coats and closely clings to the soil particles and is only displaced with difficulty ; this air film plays an important part not only in the biological activities of the soil, but in maintaining its physical condition, and exercises a vital influence in preventing water-logging of the soil particles. Ploughing the soil when it is dry, by breaking up the particles increases the area of their surfaces and with it the content of the air held in the form of the air film upon these surfaces. Ploughing when wet, however, abrades the air film and rubs it off, replacing it with water, removing the permanent air supply and bringing the soil particles into close and adhesive contact. The puddling of clay such as is effected in a pug mill depends upon this action.

Apart from the deleterious influence of compaction upon the biological processes of soil, especially nitrification, it must be remembered that plant roots have to penetrate soil by sheer mechanical pressure and that many crops fail to do this in soils or subsoils whose texture is so close as to present mechanical resistance too great for easy penetration ; the " pan " liable to occur in arable soils at the lower limit of cultivation is a familiar instance of this condition.

Drainage. The principal object of drainage is to prevent the formation or persistence of anaerobic conditions in the soil ; it is unnecessary to repeat the reasons for considering anaerobism fatal to fertility, but it may be pointed out that in a soil of average texture and fertility not only may the whole existing supply of nitrates be destroyed in a few days time by the existence during that period of

anaerobism due to waterlogging, but conditions may be set up which will seriously interfere with the process of nitrification after removal of the excess of water.

Irrigation. Where irrigation is the standard method of water supply for the crops, knowledge of the infertility factors above described is of even greater importance than in unirrigated areas. Control of the water content of the soil not only places in the hands of the cultivator the power of supplying the water requirements of his crop, but makes it essential that he should possess all the information available as to the relation between soil moisture and the numerous and complicated biological processes making for fertility or the reverse, and dependent on appropriate or mistaken use of this control. As the writer pointed out in a paper in the "Agricultural Journal of India"[1], there is great need for research and investigation into the water requirements of soils under irrigation ; such enquiries could only be effectively carried out in irrigation areas and must give due weight to the biological factor. It is probable that the highly important problem of natural fixation of nitrogen in Indian soils is more likely to be solved by study of irrigated than of unirrigated soils, and the results of the application of the solution will most probably be more readily attained in the former.

Manuring. The practice of manuring is a recognition of the depletion of soil fertility by the artificial cultivation of crops. It is of course impossible here to deal with this large subject in any way except to mention one or two points in connection with the relationship between the use of manures and the action of soil bacteria. We may consider as examples the supply of available nitrogen and phosphates as of practical interest and importance.

Nitrogen. Reference has already been made to the conditions, both favourable and the reverse, which occur in soil and which influence the conversion of unavailable organic nitrogenous food into nitrates. It has been pointed out that suitable conditions so far as air and water supply in the soil are concerned must be provided by appropriate cultivation ; it is also necessary to know something about the capacity of particular soils to deal with the sources of nitrogen in question, *i.e.*, whether the soil of an area under manurial treatment is capable of nitrifying the material available for this purpose. This introduces the interesting fact that instances have been found of soils in which not only does nitrification not occur, but examination has shown that nitrifying organisms are absent altogether. Although such soils are in most cases of a low grade of fertility and will carry only certain crops, in other instances such as some tea soils, the crop flourishes and responds to ordinary manurial applications in such a way as to suggest that nitrate nitrogen is not necessary to its growth or well-being. This of course is also the case with rice under swamp conditions, to which crop nitrates are apparently not only unnecessary but actually harmful, except in the seedling and in the latest stages of growth. In certain soils from the neighbourhood of Ranchi containing no nitrifiers I have found it possible to induce nitrification by artificial inoculation with

[1] *Agri. Jour. India*, XX, 4, p. 270.

nitrifying bacteria, but this improvement would probably not be a permanent one unless intensive cultivation and applications of lime were maintained over considerable periods.

Another consideration arises in connection with the nitrification of organic manures, this being the suitability of the latter for the process. Observation of the nitrification rate of various nitrogenous materials shows a wide variation in their suitability as evidenced by this rate ; *mahua* cake for example only nitrifies in soil after prolonged periods of time, probably owing to its content of saponin. In practice, it is important not only to keep this in mind, but to be aware of the fact that nitrification is inhibited both by unsuitable soil conditions and by the application of excessive amounts of organic nitrogenous material. Other important factors come into operation in this connection and must be taken into account, but time forbids reference to them except to mention the possibility of loss of nitrogen as nitrate under conditions where the nitrification rate is so high as to lead to removal of nitrate by leaching by rain water passing through the soil. For this reason it is frequently advisable to apply dressings of cake in separate doses during the growing season of the crop, in place of all at one time.

Phosphates. The availability of phosphatic manures is intimately connected with bacterial action in the soils to which they are applied. Two distinct styles of bacterial activity are concerned : (1) those which tend to solubilize otherwise insoluble phosphates ; (2) those whose action results in diversion of phosphate from the supply originally available for the plant.

(1) It is probable that a large proportion of the naturally available, because soluble, phosphate in the soil is in this condition as a result of acid reactions set up by bacterial activity, either by formation of organic acids or of carbon dioxide. It was originally considered that this action, generally associated with the decomposition of plant residues, such as green manures, oilcakes and cattle manure, resulted in the direct supply of soluble phosphates to the crop, and might be intensified by the method of composting mineral phosphates with organic matter. Experience, however, has yielded disappointing results with this method when utilized with the intention of obtaining supplies of soluble phosphates, and it has consequently been largely abandoned ; this in my opinion is a mistake, as the apparent failure of the method is due to the appraisement of the results in terms of directly soluble phosphate as is the practice with superphosphate, whereas so far as work at Pusa on this subject has gone it appears that changes in the condition of the original insoluble phosphate due to bacterial fermentation in the compost, take place leaving a certain proportion in a relatively available condition in the form of organic phosphorus compounds, probably constituents of the bacterial cells themselves. Evidence exists leading to the conclusion that the P_2O_5 held in this combination can serve as plant food under soil conditions, either directly owing to the death of the bacterial cells or to later changes in the soil of an indeterminate nature. My present opinion based on field and laboratory experiments is, that

bacterial action under suitable conditions is able to convert phosphate into organic combination and remove it from those influences which would otherwise tend to produce chemical reversion to the insoluble tricalcic condition ; this organic combination will later present a source of phosphate food of relatively higher availability than the tricalcic form resulting from purely chemical reversion, or existing as such originally. The practical agricultural method of securing this result depends merely upon the provision of adequate soil moisture and sufficient organic matter to promote vigorous bacterial growth and activity ; this is one of the principal functions of such operations as green-manuring.

A more specialized style of solubilization of phosphates occurs in the case of that effected by sulphur-oxidizing bacteria. Time does not permit of anything more than reference to this process which I described in an article in the " Agricultural Journal of India " (January, 1924) and at the last meeting of the Board of Agriculture at Bangalore. It is of course an artificial method depending on the use of sulphur and bacterial cultures capable of producing sulphuric acid therefrom, but it is of interest to note that the method is now being tried on a commercial scale as a source of phosphatic manure.

(2) With reference to that class of bacterial action resulting in removal of phosphate from the root range of the growing crop it must always be remembered that bacteria are plants and as such will compete with the agriculturist's crop for plant food in the soil. We have seen that this happens in the case of nitrates and there is reason to believe that it is an equally important phenomenon as applied to the supply of phosphates ; thus superphosphate when applied to a soil is partly taken up by the crop, partly reverted by chemical action, and partly absorbed by bacteria. As we have seen above, there is reason for supposing that this last portion remains relatively available as compared with that which has undergone chemical reversion, so that there is no reason for treating this form of bacterial activity as one likely to produce infertility in the soil.

On the other hand practical experience shows that in our Pusa soils the combination of green manures with superphosphate produces the best results, so that on the whole we may consider bacterial action in the soil as a favourable influence so far as supplies of available phosphate are concerned, and the aim of the agriculturist should therefore be to encourage such activity as much as possible. This can be done mainly by maintaining adequate supplies of organic matter, and the inclusion of the usual methods of doing so in agricultural practice forms another instance of a correct method based on empiricism derived from experience.

The selection of crops and use of improved varieties is too large a subject to be dealt with here. One point may be referred to and that is the selection of varieties with special reference to the depth of root range of the plant ; here we come in direct contact with soil conditions involving degrees of anaerobism or the reverse, varying in accordance with the character of the soil and its agricultural treatment. Knowledge of the unfavourable effects of anaerobism such as have been described

above will not only serve as an additional incentive to the use of such agricultural operations as will tend to diminish this condition, but may lead to the use of shallower rooted varieties in situations where soil and climate may render this additional precaution necessary.

In conclusion, it may be emphasized that so far as soil fertility is concerned, this condition or its opposite can never be ascribed to one simple cause alone but is associated with the interaction of several. It is incorrect to say, for example, that lack of oxygen causes infertility only because plant roots require oxygen for healthy growth ; we have seen that conditions in the soil producing an insufficiency of air tend to cause infertility through the combined operation of a number of factors, some positive such as the production of toxins and of colloids by anaerobic bacteria, and others negative such as the failure to form nitrates for want of sufficient oxygen to maintain the proper bacterial balance in the soil. The complete investigation of the reactions and especially the bacterial activities underlying and ultimately responsible for the complex changes and conditions in a soil, is essential and necessary for any understanding of the problem of soil fertility ; in this country especially, owing to the high soil temperatures which prevail during a large part of the year, and the correspondingly rapid bacterial changes resulting therefrom, any advance towards solution of this problem must depend upon adequate recognition of the intimate connection between soil fertility and soil bacteriology.

SELECTED ARTICLES

THE DIRECT METHOD IN THE MICROBIOLOGICAL STUDY OF THE SOIL.*

BY

S. WINOGRADSKY.

[*Translated by Professor N. Gangulee, University of Calcutta.*]

Before taking a new step one generally feels a tendency to set up a balance of acquired notions, to refresh one's memory, and to combat the illusions which, in spite of us, become implanted in our minds ; all this is done the better to choose the direction of our efforts and the programme of the work. Under the influence of this tendency, the idea came to me to draw a picture of the present state of our knowledge of the microbiology of the soil ; a very sincere picture born in the seclusion of the laboratory, without any idea of popularizing this subject by arousing public interest. This done, I shall endeavour to show in outline how, in my opinion, it would be necessary to set about making progress in a field which has already been for some time in an almost stationary state.

Slow progress of the microbiology of the soil.

More than half a century has passed since the announcement of Pasteur's idea concerning the rôle of micro-organisms as destroyers and mineralizers of organic matter. The foundation-stones of an edifice of microbiology appeared to have been laid, but the building itself has long tarried in construction. In fact, whilst the bacteriology of fermentation had already acquired a considerable development and whilst pathological bacteriology advanced with giant strides, the bacteriology of the soil only marked time, having encountered, at its very commencement, bacteria, unknown in properties and difficult of management. A new method, termed *elective culture*, at last triumphed some 30 years ago, triumphed over obstacles, and since then one has learned to isolate without too great difficulty (but also none too easily) different soil bacteria, and to reproduce in pure culture different processes which have bearing upon agricultural science. Here we have in a few words the resumé of a long period of research and this is where we now are.

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* The original appeared in *Chemie and Industrie*, Vol. XI, No. 2, 1924.

Grouping by functions.

At present one cultivates in our microbiological laboratories a fairly large number of bacterial species, isolated by different workers from different natural media. With these, conventional nutritive media are inoculated and reinoculated in tubes or flasks. They are submitted to detailed physiological experiments. As far as possible they have been grouped according to their functions; for example, ferments of albuminous matter, producers of ammonia, ferments of that widespread amino body, urea, ferments of carbohydrates.

When we can grow the latter on nitrogen-free media, they call for our attention as fixers of atmospheric nitrogen. There is finally the little group of nitrifying bacteria, consisting of species widespread in the whole of the earth's crust. This group is unusual from the physiological point of view, and even peculiar amongst all living beings. Prototrophorous organisms, that is to say those capable of chemical synthesis, procuring for themselves the necessary energy by the oxidation of inorganic substances—ammonia, nitrite, etc.,—whose nutrition is purely mineral to such an extent that the best foods, sugars and albuminous substances, only paralyse them—are bacteria truly *sui generis*. In the sulphobacteria, the ferrobacteria and a few other small groups which are more rare, we see, according to some workers, the last type of a primitive physiology that has given way to a dominant physiology which takes its energy from complex organic substances, chiefly sugar.

That all this is a great acquisition from the physiological point of view no one will deny. We owe this to pure microbiology almost without any idea of application. After Pasteur, the study of the new world of bacteria pushed itself to the fore. It was necessary to learn to handle bacteria to avoid confusing them; this was extremely difficult at the beginning—to take good note of their morphological characters, and to test their chemical capacities. To isolate and study them in a state of purity was then an indispensable condition of microbiological work.

Application to agricultural science.

In spite of the progress of microbiology, agricultural science could not fail to see the assistance it could derive from it. The discovery of nitrifiers and fixers of nitrogen has above all been decisive on this point of view. Then it was that one began to speak clearly of an agricultural microbiology. Is it a new branch of microbiology with its own method specially elaborated with the idea of attacking agricultural problems? No. No new method has been devised. The elements for the new branch have merely been borrowed from the mass of already acquired knowledge. The agricultural microbiologist or he who desires to become one, simply places himself before the collection to search out bacteria which may be of interest to agricultural science.

He has been content to find there the ammonifiers, the production of ammonia being a very widespread phenomenon in the soil and much studied by agricultural chemists. He has been happy to find nitrifiers, certain that with them he has had to deal with quite authentic soil bacteria whose function is well known. He has been pleased to find fixers of nitrogen at last imprisoned in tubes after more than half a century of resounding controversy. Without hesitation he can add to these the urea ferments which are so active in stables.

As for the multitude of species which remain after this choice has been made, the functions of which show in less relief, he can with reason decide to hold them responsible *en masse* for the general phenomena, so to speak, of which the soil is constantly the seat. Amongst such reactions are the production of carbon-dioxide, decompositions, oxidations and reductions.

HAVE WE AN AGRICULTURAL MICROBIOLOGY ?

With all these elements united, the new branch appears to have been constituted about fifteen years ago. It was about 1910 that there appeared from the prolific pen of Professor Löhnis the first works on agricultural microbiology. He published both of these about the same time : the *Vorlesungen* or " Studies ", and the *Handbuch der Landwirtschaftlichen Bakteriologie* or " Treatise on Agricultural Bacteriology." The latter is a book of about a thousand pages, in which the author has committed the grave error of exhausting all the literature that has any bearing whatsoever on agriculture and agricultural industries, without throwing any light on these ill-matched data by a competent criticism. Other works have appeared in all languages and continue to appear, thus bearing witness to the interest which the public shows for these questions.

The authors of these works have certainly the honour of having simplified for those interested the means for self-instruction and the way to find out how matters stand. Whilst doing them justice in this respect, we cannot hide our opinion that agricultural microbiology, as a definite science, does not yet exist ; it is still to be created almost in all parts, beginning with the technique. We particularly thank Kayser for having entitled his two little volumes of the agricultural encyclopædia, " Microbiology applied to the fertilization of the soil " and " Microbiology applied to the transformation of agricultural produce." In both cases there is only an application pure and simple of the notions acquired in pure microbiology. Only in the second of the two, which does not interest us here, has this application an air of confidence which it does not possess in the first.

As a matter of fact in the ordinary dairy and in the cheese dairy, in the practice of steeping and of storing fodder in a silo, the microbiologist employs a medium better known and less complex, especially from the point of view of microbiology, than the soil. If he wishes to study the part played by a type of bacteria in a pot of milk, in a cheese paste, in fodder or elsewhere, he has only to turn to direct

experiment which is the best source of information. It is the same for the pathological biologist who does not take a step without an experiment *in vivo* which alone allows him to follow directly the action of a bacterium as a morbid agent and the reaction of the living host. The case is entirely different when it concerns questions of the microbiology of the soil.

Difficulties in the study of the microbiology of the soil.

I need not give a list of the characteristics of this natural medium. All that interests us at the present moment is that it is a living medium saturated with a crawling mass of microscopic creatures, of a variety defying all imagination. The question is how to begin to study the rôle of any type whatsoever in the corners and recesses of the soil? Being opaque it betrays practically no sign of bacterial life however abundant it may be. Difficult of microscopic study, variable in its composition, and poor as a culture medium compared with our standard media, it has very rarely been employed for the culture of bacteria and then only in the sterile state. It is useless to say that in this state it is *the soil*: it is merely a medium; for, what characterizes the soil are its biochemical qualities, which are inseparable from the organisms which multiply there, or which lie dormant in the state of spores. Experiments with the dead medium do not give us what we are looking for: they would not be more direct than the others. As for microbiological experiments with fresh earth in the natural state, these have scarcely been thought about. How would it be possible to follow the rôle of interesting species in so slightly accessible a medium with such a heterogeneous population? And further, one does not agree with the first principle of the current method, which accepts only the results obtained from pure culture.

The road of direct experiment appears closed without remedy and one was forced to accept this state of things. This has been done by tacitly admitting, unconsciously perhaps, *that the rôle of different bacteria in the soil is the same as that which they take in pure cultures in artificial media. In other words, one has not hesitated to apply to natural media the results obtained in pure microbiology.* This procedure is certainly not justifiable.

Criticism of the current method.

Difference in the conditions of life.

There are two classes of consideration which are opposed to this manner of looking at things. The first is so obvious that it almost thrusts itself forward. It is certain that the conditions of pure culture in artificial media are not comparable with those of the free natural existence of any type of bacteria whatsoever. Let us admit that, even in the case of bacterial species, there is an inherent tendency to react always in almost the same way towards substances submitted to their action. All

the same, it is not possible for us to conclude as to the immutability of their reactions to the extent of their not allowing the physico-chemical properties of the medium to influence them. But this is not all. There is a condition of a biological nature which could modify, and that very profoundly, the function of a bacterial type; *this is the condition of pure culture.*

We must bear in mind that, cultivated in the pure state, sheltered by the best conditions for life, it is artificially removed from the incessant struggle between the different bacterial species, the aim of which is the appropriation of the material sources of energy. Now this struggle, which is constantly going on in the natural medium, is of very great importance. Without doubt it is this which determines the fate of the different species, and, to a great extent, their functions also. Protected in a culture-tube a specific type of bacteria can assume a definite rôle which it will not take in the soil. Its natural rôle would, in consequence, be reduced to something quite different from what obtains in the laboratory ; from being naturally inactive it could become active, or perhaps the opposite.

Let us recall once more the variety of laboratory experiments to which bacteria are submitted and in which they are forced, to a certain extent, to enlarge upon their natural functions. The contrary must take place in the soil, where the action of a species is, as it were, confined to a groove, narrowly limited by the action of other species. By the very fact of this merciless struggle, which scarcely ever ceases in the natural medium, this action is inseparably bound to a certain optimum set of conditions, outside which it is condemned to remain insignificant or non-existent. That is to say, in Nature these functions must be *more specialized*, more limited than in the laboratory where they depend largely on the aims and artifices of the experimenter.

VARIATION IN CULTIVATED SPECIES.

Let us pass on to another class of considerations less evident, and unfortunately still less familiar to microbiologists, but none the less worthy of our full attention. Up to the present we have made a tacit assumption that bacteria cultured in tubes are identical as species, varieties or races, with their ancestors which formerly lived in a free state in the soil. On looking at this more closely, we find that we have forgotten one fact that is very common in the experience of agriculturists and horticulturists. This is that cultivated plants sprung from wild ancestors are inclined to form varieties or races so different from their prototypes that all identity seems to have been lost. Why should it be different with bacteria ? One cannot confirm this, above all when one considers that bacterial generations follow each other with such rapidity that one year of bacterial life is equivalent to one or more centuries in the life of any phanerogam. This being so, there are, in our laboratories, many rows of carefully preserved cultures which have already celebrated many jubilees,

It is difficult to reply to the question as to how long it would take a soil bacterium, sheltered under the best vital conditions and overfed on our nutritive media, to form a new variety. At present there is no criterion to distinguish a natural species from a cultivated variety, but it is necessary to find one, or, at any rate, carefully to avoid confusing the two.

For that matter, we have only to follow, in principle, the example of the microbiologist of fermentation who distinguishes between natural and cultivated yeasts in order to employ the latter only in his vats. On the contrary, the soil microbiologist should avoid calling in the action of cultivated varieties in order to explain natural phenomena. It must be remembered that *culture* is only the counterpart of horticulture and that a microbiologist can no more gain a knowledge of the microbiology of the soil in a vat of pure culture, than a botanist can study the flora of a country in a greenhouse.

In conclusion, we may say that one may not apply ideas obtained from work on pure culture in conventional media directly to the microbiology of the soil. This work has enabled us to gain an insight into bacterial physiology but it cannot, in our case, do more than lead us to analogies and hypotheses which must be verified by direct experiments under conditions as nearly natural as possible.

Our opinion, as we previously stated, that the microbiology of the soil does not exist, now seems to be resting on firm arguments. Agriculture and the agricultural chemist with their soil, on the one hand, and the microbiologist with his tubes of gelatine on the other, still watch each other from afar, with interest undoubtedly, but without lending each other a hand or endeavouring to unite their efforts. The only bond which unites them is the sample of earth which the latter goes to fetch from time to time—but as rarely as possible—to start off his crude cultures ; a very frail bond indeed, for as soon as he succeeds in obtaining the type of bacteria he requires, in pure culture, he has all that interests him.

(To be continued.)

THE NUTRITION OF CATTLE.*

THE subject of the feeding of cattle assumes importance from the large part their products play in human dietaries. An accurate knowledge of their metabolism and nutritive requirements, apart from its intrinsic scientific interest, may lead both to more economical methods of feeding and at the same time to an improvement in the quality and quantity of the products, meat and milk, obtained from them. In this survey a brief account will be given of some recent work on the energy, protein and mineral requirements of these animals, with special reference to the production of milk in dairy cows.

The measurement of the energy requirement resolves itself into the problem of estimating the heat given out by the animal, since to maintain the body in equilibrium a similar amount of energy must be taken in in the food. The output of heat can be measured directly by placing the animal in a calorimeter, or chamber in which the heat emitted is measured by the amount absorbed by a current of cold water circulating through the chamber; the analysis of the ingoing and outgoing air at the same time will give the consumption of oxygen and output of carbon dioxide during the experimental period. The method requires the use of elaborate apparatus, so that in practice the indirect method of determination of the heat output is more frequently employed. In this the output of carbon dioxide and consumption of oxygen are determined over a short period, and from these data, together with the value of the respiratory quotient, *i.e.*, the ratio of carbon dioxide produced to oxygen consumed, a value can be found for the heat production which is sufficiently accurate for most purposes. The respiratory quotient conveys information as to the types of foodstuffs which are being oxidized in the body, and this information is essential since the heat produced varies according to the type of food stuff, protein, fat or carbohydrate utilized.

The problem of estimating the heat output in the case of cattle has been still further simplified by W. W. Braman (*Jour. Biol. Chem.*, 1924, Vol. LX, p. 79): tht only data required are the output of carbon dioxide and the amount of food taken. In a large number of experiments he has found that the ratio heat/carbon dioxide is highest in starvation and falls steadily with increase in the amount of food eaten, the heat production increasing more slowly than the carbon dioxide formed. The change is due to the fact that in starvation most of the heat produced comes from the oxidation of fat, which has a high calorie value, whereas the food is chiefly carbohydrate with a relatively low calorie value. These experiments enable an investigator, by estimating the carbon dioxide production and noting the food consumption, to determine the approximate heat output by applying

* Reprinted from *Nature*, No. 2909 (1925).

the formula given by the author or by reading from the graph relating the ratio heat/carbon dioxide to the food consumption, which is approximately a straight line. The heat output thus calculated agrees closely with that actually observed in a calorimeter.

A more elaborate, but more accurate, indirect method of estimating the heat output of cows has been utilized by J. A. Fries, W. W. Braman, and D. C. Cochrane (*U. S. Dept. Agri. Bull.* 1281, 1924). The method depends on the fact that in an animal which is maintaining its weight, the heat output must equal the energy of the food actually utilized by the body during the experimental period. Of the food taken, some is not absorbed and some is excreted in an incompletely oxidized form. The digestibility of the food is usually estimated by taking the difference between the amount eaten and the amount excreted in the fæces, but the authors point out that in cattle, bacteria in the intestine play an important part in digestion. At the same time, one of the products of their fermentative action is a gas, methane, whilst the process itself is accompanied by an output of heat. The methane produced has been estimated in the respiration calorimeter, and the heat of fermentation from the ratio of methane to carbon dioxide in the products of fermentation. The results show that whereas the digestible portion of the food appears to be about 66 per cent. of that taken by estimation by the usual method, by taking account of the above two factors also, only about 50 per cent. of the food consumed is actually absorbed and available for energy and heat production. The actual energy of the food was determined directly by the bomb calorimeter, and thus the actual energy available to the body is known. Nearly all this energy is available for maintenance, growth (or increase of protein or fat in the body), work and the production of milk, about 10 per cent. being lost in the processes of digestion and in the formation and elimination of the excreta. The authors have compared the heat production calculated from the available energy of the food with that actually observed during the same period in the respiration calorimeter and have obtained a very good agreement. The result indicates, in their opinion, that this method of "indirect calorimetry is sufficiently accurate for purposes of research in the feeding of farm animals."

Of the energy available to the body in the food, about half is required to maintain the body-weight constant; the remainder can be utilized for increase in body-weight or for milk production. The data show that a larger proportion of the energy available is found as energy in the milk than in any increase of body-weight; the process of milk formation appears to be more economical than that of body tissue and fat formation. The result suggests that the food materials are available directly for milk formation and do not have to become body tissue first and milk later. Of the available energy, 90 per cent. or more can, under certain conditions, be utilized in milk production.

It is of course essential that the conditions of the experiment should be kept as constant as possible in different experiments. One factor which may introduce

a disturbing element is the relative amount of time spent by the animal in the standing and lying positions. This subject has been considered in more detail by J. A. Fries and M. Kriss (*Amer. Jour. Physiol.*, 1924, Vol. LXXI, p. 60). They found that allowance must be made for the taking up of heat by the floor on which the animal lies in the respiration calorimeter, this heat being afterwards given up when the animal stands, making the heat output of this period too high. The magnitude of this error can be ascertained by estimating the carbon dioxide output and assuming that the ratio heat/carbon dioxide is a constant. Making this allowance, it was found that the heat output of a 400 kgm. cow increased by about 25 calories per hour on standing. The authors recommend that the heat production be calculated to a standard day of twelve hours lying and twelve hours standing, so as to obtain uniformity in the expression of the results obtained by different observers.

It is of interest to note that in the later stages of gestation, a cow appears to require about 2 per cent. more food for maintenance than a non-pregnant animal of the same weight.

The utilization of protein in milk production has been considered by J. A. Fries, W. W. Braman and M. Kriss, and also more recently by E. B. Forbes and R. W. Swift (*Jour. of Dairy Science*, 1924, Vol. VII, p. 11; and 1925, Vol. VIII, p. 15). The two sets of experiments agree fairly well in showing that in well-fed animals the utilization of protein for milk production is about 40 per cent. of that available for this purpose (that is, the digestible protein of the food less that required for maintenance). With decrease in the protein intake, however, the former authors found that a larger proportion of the available protein, up to 85 per cent., became available for milk production, since the nitrogen excretion falls *pari passu* with the drop in nitrogen intake, whilst the nitrogen in the milk remains almost constant. With a higher percentage utilization, however, the amount of milk produced tends to fall off, being increased again with increase in the protein intake. The optimum nitrogen intake was an amount of available nitrogen about 10 per cent. greater than the nitrogen found in the milk produced. The animals maintained their weight, whereas with a larger protein intake the animals gained in weight by the deposition of fat, together with an increased formation of body tissue. The fact that with low nitrogen intakes the quantity of milk produced tends to fall off in a cow producing a large amount daily, suggests that the level of optimum intake of nitrogen as regards the nitrogen of the milk is not the optimum level for the production of a large quantity of milk, which contains both fats and carbohydrates as well as protein, and therefore that the animals should be well fed, if the best results as regards milk production are to be obtained.

In addition to the proteins, fats and carbohydrates present in milk, account should also be taken of its vitamin and mineral content in estimating its quality. Ultimately these factors come from the food, in which they should therefore be present, but the amounts passed into the milk may be greater than can be absorbed

in the food, leading to a depletion of the animal's own stores. This appears to occur especially in the case of the calcium of the milk. During liberal milk production on winter foodstuffs there may be a definite loss of calcium from the body; on fresh foodstuffs this loss is less or may be absent (E. B. Forbes, Washington Government Printing Office, 1924). This effect is quite probably to be related to different amounts of vitamin A present in the dry and fresh green foodstuffs, but it seems to be clear that the cow should be encouraged to store as much calcium as possible in her body during her dry periods by the giving of calcium, for example, in the form of bonemeal, in addition to an adequate supply of fresh green foodstuffs. It is possible also that the addition of sodium phosphate to a dried ration may increase the milk yield after parturition, suggesting that this food may be deficient not only in calcium but also in phosphorus, or that the availability of these elements present in the food is impaired by a deficiency in the fat-soluble vitamin A.

The general result of all these investigations is that a dairy cow should be fed on an abundance of fresh green food, containing a supply of protein, etc., which is sufficient to maintain both the quantity of the milk produced at a high level as well as its protein, mineral and vitamin content. If this be done, the supply of energy will certainly be adequate also.

THE SIGNIFICANCE OF MILK RECORDS.*

Not only do milk records assist the herd owner in selecting the heifer calves from his best milkers to be retained for coming into the herd three years hence, but they are also invaluable in the selection of a bull. This statement was made by Mr. G. H. Garrad in a paper on milk records at the recent conference on dairy cows at the Midland Agricultural College.

Later in his paper he stated that the influence of agricultural shows in the development of our milk breeds has been gradually diminishing, because as an indication of commercial value the agricultural show takes second place to the record of performance.

The only certain test of a cow's ability to milk, he said, is the evidence of the milk recording dial, and those who start keeping milk records for the first time are usually astonished at the disclosures that quickly follow. With the evidence of the milk-record sheet, the herd owner has the necessary information on which he can weed out his unprofitable cows, and by raising his standard year by year and disposing of such cows as do not come up to that standard he is in a position gradually to increase the output of milk from the same number of cows.

The existence of milk records assists the herd owner in selecting the heifer calves from his best milkers to be retained for coming into the herd three years hence. But milk records are also invaluable in the selection of a bull. Like begets like, and we know that the father and the mother exert an approximately equal influence on the dairy qualities of the offspring. Seeing that the bull that fathers the herd has some 50 sons and daughters in the course of the year, whereas the cow only has one or two, it follows that the bull is far more important than any individual cow. A bull that is to be useful to the dairy farmer must carry a guarantee not only as regards the outward appearance and the constitution of his offspring, but also as regards their milking ability. This is merely a matter of ancestry.

The larger the number of good-milking ancestors that the bull can count in his pedigree, especially amongst his nearest relatives, the more likely he is to transmit these milking qualities to his daughters.

Breeding up the herd.

Thus the milk-recording movement will become increasingly valuable in the development of our dairy breeds as it becomes older and more widely established. A bull's prepotency, *i.e.*, his power of transmitting his character to his offspring, depends on the length of his pedigree, the number of generations for which he has been bred to a particular pattern. If he is used for mating mongrel cows that have never been bred to any particular pattern, his influence will be so much the

* Reprinted from *The Farmer and Stockbreeder and Agri. Gazette*, No. 1880 (1925).

greater. The worse the cows, the more important it is to have a good bull, because the greater is the scope for improvement and the stronger is the influence of the bull. Breeding experiments have shown that by the use of carefully selected bulls it is possible to build up a high-class herd from the poorest herd of mongrel cows in three or four generations.

In recent years the influence of agricultural shows in the development of our milk breeds has been gradually diminishing because as an indication of commercial value the agricultural show takes second place to the record of performance. Nor is the fact that a cow is a pedigree animal a guarantee that she is a good milker. At the London Dairy Show the non-pedigree Shorthorns consistently do better in the milking trials than the pedigree cattle, and in most commercial dairy herds the mongrel Shorthorns milk better than the pedigree Shorthorns. The record of performance is the real test. Unfortunately a bull does not produce milk, so we cannot tell directly his milking ability, and we must rely on the milk records of his nearest female relatives, his dam, granddams and, if available, his full sisters.

"By their fruits."

On any dairy farm where the cattle are homebred, the external influence of the bull can be seen by a glance at the young stock. But "by their fruits ye shall know them," and it is only when the heifers come into milk that the influence of the bull on the milk yield of the herd is apparent. Real improvement in a herd means that the heifers reared to maintain the stock are better milkers than their dams. By comparing the milk records of a number of heifers, bred from the same bull, with the milk records of their mothers when they were first-calf cows a clear indication is given as to whether or not and to what extent that bull is improving the milking capacity of his herd.

Daily recording.

Continuing, Mr. Garrad said he was entirely in favour of daily recording as opposed to weekly recording. Weekly weighings are approved by the Ministry of Agriculture, and at the end of the year the total yield obtained by weekly weighings will be within about 2 per cent. of the truth, but daily recording, once it becomes a habit, entails very little trouble and is not so likely to be forgotten. Daily records are far more instructive, and they draw attention at once to a cow whose milk yield has dropped down a pound or two since yesterday. Inquiry is made at once as to the cause of it. Is she bulling? If so, the information is valuable. Is she ill? If so, the necessary treatment or isolation can often be adopted before the mischief has gone too far. If the milk yield of all the cows has dropped they may have been over-driven or wrongly fed.

Inefficient milking is responsible for an enormous amount of loss in the cowshed, and if each milker is made to put his initials when he enters the yield of each cow

on the milk record sheet, and the figures for each man are added up at the end of a fortnight or a month, it is easy to find out which are the most efficient milkers and which would be better employed elsewhere. Some herd owners organize competitions amongst their milkers. Each one milks each cow a certain number of times, and at the end of a month the man who has obtained the most milk, as disclosed by the milk record sheet, wins the prize. Efficient milking may easily make a difference of 10 per cent. in the yield and a still greater difference in the percentage of butter fat. Some herd owners give a bonus to the milkers at the end of the year for every gallon the herd average is above 700, 800, 900, or 1,000 gallons, as the case may be, according to the milking capacity of the herd.

How recording can help?

Milk records in themselves are valueless; their value depends entirely on the use that the herd owner makes of them. They can be used in many ways directly or indirectly, and can have a most stimulating effect both on the owner and the milkers. There is rivalry between cow and cow and between one milker and another. An increased or decreased yield on any particular day gives rise to speculation and investigation as to the cause, the effect of change of feeding is watched in connection with the milk yield, and there is an altogether different atmosphere amongst the workers in the cowshed. Milk recording has a strong educational value, and tends to greater interest and efficiency all round on a farm where the milk records are kept and interpreted intelligently.

Selling recorded stock.

Cows sold with officially certified milk records make much higher prices in the market than cows sold without a record, but in his opinion it would be in the true interests of the milk-recording movement if, when milk-recorded stock are sold, some indication were given as to how the cows had been fed and managed. Three-times milking and forceful feeding has sometimes been adopted for the sole purpose of getting high milk records for sale purposes. Such practices throw milk recording into disrepute, and somehow or other must be stopped. There is also need of some uniform system of publishing milk and butterfat records. Sometimes they are stated for a lactation period and sometimes for a period of twelve months, sometimes in pounds and sometimes in gallons. In England the gallon is usually taken as equivalent to 10¼lb., in Scotland as 10 lb., whilst in America it is only 8⅗lb. Mr. Mackintosh, of Reading, has made a strong case in favour of the milk yield being always stated in terms of pounds per lactation period, the lactation period being stated in days, and the date given of the next calving and the number of days the cow was dry before the next calving. The weight of butterfat produced in the lactation period, if known, should be stated in pounds, and the method of calculation of the weight of butterfat should be specified.

NOTES

MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA.

THE number of factories making sugar direct from cane in India during the season 1924-25 remained the same (23) as that in the season 1923-24. Ten of these factories are situated in the province of Bihar and Orissa, eight in the United Provinces, two each in Bombay and Madras Presidencies and one in Assam. We are much indebted to the proprietors and managing agents for furnishing the statistics regarding the working of their factories.

The table below shows the total amount of cane crushed and sugar made by the factories in (1) Bihar and Orissa, (2) United Provinces, and (3) other provinces of India. The production of sugar direct from cane by modern cane factories in India totalled 920,305 maunds or 33,745 tons during the season 1924-25, as compared with 1,044,856 maunds or 38,312 tons during the previous campaign.

Table showing the production of refined sugar in India by modern factories making sugar direct from cane during the two seasons 1924-25 and 1923-24.

	Cane crushed		Sugar made	
	1924-25	1923-24	1924-25	1923-24
	Mds.	Mds.	Mds.	Mds.
Bihar and Orissa	5,538,418	6,738,391	440,966	509,548
United Provinces	3,216,198	5,258,728	232,717	368,791
Other Provinces of India	3,028,015	1,996,917	246,622	166,517
TOTAL	11,782,631	13,994,036	920,305	1,044,856

There was thus a decrease of 124,550 maunds in the amount of sugar obtained during the season 1924-25 as compared with 1923-24. This decrease is due to inadequate supplies of raw material and the higher prices of *gur* which induced ryots to prefer making *gur* to selling the cane to factories. Secondly, the acreage under cane in India was also smaller than in the previous seasonby 388,000 acres. If we take into consideration the figure of the total production of refined sugar from cane during each of the last five years, it would be seen that the season 1923-24 was an exceptional one in this respect and so forms an unfavourable basis for comparison with this year.

It will, however, be interesting to note that the factories have shown a slight improvement in their efficiency, and it is especially noticed in case of some factories situated in Bihar. If we take all-India figures we find that on an average 12·8 maunds of cane were required to produce 1 maund of sugar in the season 1924-25, as compared with 13·39 and 13·28 during the two campaigns 1923-24 and 1922-23 respectively. In this connection it may be mentioned that some of the factories in

Bihar obtained improved varieties of Coimbatore canes for crushing during this season. These canes were first distributed by the Sugar Bureau after a thorough mill trial to the growers in Bihar in February 1923. During the current season, these canes have been extensively taken up by both large and small growers, and it is anticipated that with favourable weather conditions experienced this year the results will be more satisfactory for the group of factories working in North Bihar in the season 1925-26.

During the season 1924-25 India's production of molasses by modern factories making sugar direct from cane totalled 498,030 maunds, as compared with 622,473 maunds and 348,024 maunds during the two seasons 1923-24 and 1922-23 respectively. The decrease is due to the smaller amount of cane crushed this year and also improved efficiency of the factories.

Statistics regarding the production of refined sugar by refineries in India during the season 1924-25 will be collected and published in due course. [WYNNE SAYER.]

A NEW USE FOR NITRATES.

THERE seems to be little prospect that nitrates will be able to compete seriously with sulphate of ammonia for use as manures in Bihar, where saltpetre is produced on an extensive scale for export. This latter salt has, however, long been used to a small extent locally, by planters, for cooling purposes; for which it is only moderately effective, owing to its relatively low solubility at ordinary temperatures as compared, for instance, with nitrate of soda, of which more than five times as much will dissolve in water at the freezing point, absorbing nearly four times as much heat. With nitrate of soda temperatures near the freezing point can be obtained using water at the ordinary temperature, even in the hottest weather.

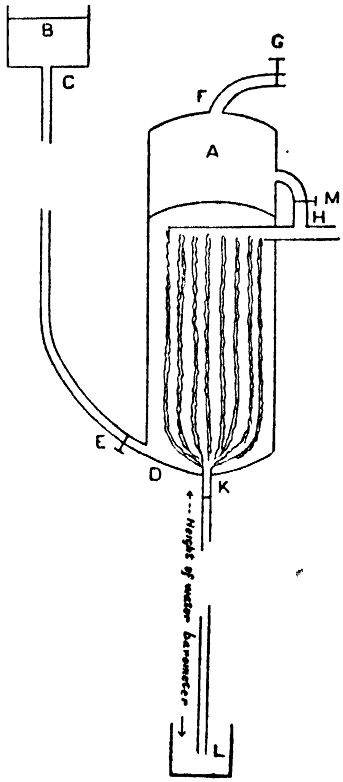
At high temperatures, however, saltpetre (KNO_3) is far more effective because its solubility increases very rapidly as the temperature rises, so that at a temperature of 160°C., and with an absolute pressure of about 35 lb.* per square inch, approximately 6½ lb. of the salt is dissolved in a pound of water. The amount of heat absorbed by solution in this proportion is more than sufficient to evaporate the whole of the water, without any further addition of heat and without any fall of temperature, if the pressure is removed.

There seems to be no reason why this fact should not be turned to account as a means of continuously recovering the salt from a cooling mixture and at the same time utilizing the heat absorbed by its original solution in the following manner.

A cylindrical boiler, A, as shown in the diagram on the next page, is nearly filled with saltpetre moistened with water introduced at D, from a tank B, through a pipe C D provided with a cock at E.

* The solution of so much salt would reduce the pressure of the vapour to that of pure water at a temperature of about 126°C.

The vapour above the saltpetre in A may be superheated by an electric current, and the steam led off by a pipe F G provided with a cock at G, and, after utilization for heating or other purpose, may be returned to a condenser HK situated in the mass of saltpetre in the boiler. After condensing the water may be allowed to escape into a tank L through a pipe KL of a vertical height greater than that of the water barometer. Thence it can be pumped back into the feed tank B.



If the vapour be heated to a temperature above 160°C., with the cock G closed, and be allowed to escape through a short pipe leading direct into the condenser and provided with a cock at M, the mass of salt in the boiler will be heated from the upper surface downwards, and will begin to dissolve rapidly in the upper part of the boiler. The level of the salt, which must be observed by means of a gauge, can be maintained by dissolving saltpetre in the feed water in B, so as to increase the proportion of saltpere to water in the boiler as the temperature of the upper part rises. The lower portion will remain comparatively cold because of the introduction of the feed water and consequent rapid solution of the salt. When the lower portion begins to warm up owing to the excess of heat applied to the upper portion, and the level of the water in the down pipe KL begins to fall owing to the rise of pressure in the condenser, the current can be switched off, the cock at M closed, and the steam drawn off for use, under control of the cock at G.

Provided excess of steam is not consumed between G and H, the temperature in the upper part of the boiler will now be maintained solely by the crystallization of the salt at the evaporating surface—the amount of salt in solution at 160°C. being, as already stated, more than sufficient to give out, on crystallization, the heat necessary to evaporate the water in which it is dissolved.

But as no heat is now being supplied from outside, while heat is being used and wasted between G and H, the remaining heat will not be sufficient to maintain the temperature in the condenser, and the temperature of the lower part of the boiler will fall and the condensed water will ultimately emerge at a lower temperature than the feed water—being cooled below the temperature of the surroundings by the continual solution of the salt in the feed water in the lower part of the boiler.

If the condensed water is returned to the tank B at a temperature of less than 10°C., the solution of the salt would reduce the lower part of the boiler below zero if

no heat were absorbed from outside. But the mixture of the water and salt may be effected in a series of pipes into which the saltpetre sinks by gravitation, and so arranged that the lower portions constitute a system for cooling an enclosed space while the upper portions are exposed to the air and light, with a view to warming the solution as much as possible before admission to the condenser. At 20° C., 1 lb. of water will, if sufficient time be given, dissolve approximately 5 oz. of saltpetre, absorbing as much heat in the process as would raise the temperature of 1 lb. of pure cold water by 26° C.; and there should be little difficulty in raising the solution in the mixture to this strength at a higher temperature during the daytime, in India, by comparatively slow circulation through an arrangement of pipes such as that suggested. The amount of energy so taken from the surroundings would in that case be equivalent to 26 × 1,400 (=36,400) foot pounds, which would give a constant supply of one horsepower for every pound of water circulated per minute, with a margin for waste by radiation of heat and for raising the condensed water some 120 feet from the tank L to the tank B.

The total amount of heat circulated in the steam would of course be very much greater, being that necessary to evaporate the water at the temperature and pressure postulated; but of this total of some 500 thermal units per pound of water evaporated, the 26 units continuously supplied from outside—approximately 5 per cent.—would represent the maximum of power that could be taken from the engine (even if no heat were lost by radiation), on the assumptions made above, without reducing the temperature of the evaporating surface below the point at which automatic working with saltpetre is possible. Though almost any engine could be run at a higher efficiency than this, to do so would cool the surface of the mixture, and put a stop to the evaporation.

There are of course other crystals and other solvents which form cooling mixtures at a far lower temperature and could be used to obtain much more power from any given surroundings; but, if we confine ourselves to those named, even in cold countries where it may be necessary to use fuel to supply additional heat, the absorption of the whole waste heat of the steam in the condenser, by the solution of saltpetre or nitrate of soda and its recovery within the boiler itself, instead of arranging to cool the condenser by a stream of water which carries away as waste 70 per cent. of the heat of the fuel, would increase the power obtainable from the fuel more than threefold.

However, to return to India, it is unnecessary to enlarge upon the advantages that would accrue to the farmer from cold storage for his products in the hot weather and monsoon, combined with a supply of steam even at the low pressure suggested. Much greater cooling effect could be obtained by using nitrate of soda; but automatic working could only be secured in that case by using a very high pressure boiler. Otherwise it would be necessary to continue to supply a modicum of heat to the upper part of the boiler to supplement the inadequate supply provided by crystallization from a relatively weak solution at the surface

of the salt. The principle has therefore been illustrated by means of saltpetre for the sake of simplicity.

The figures, given merely for the purpose of a quantitative example, do not pretend to accuracy. In fact, the writer claims no considerable acquaintance with chemistry, physics or engineering; and it is partly this that has emboldened him to venture where those with a scientific reputation at stake may well have feared to tread. He has, however, done his best, by reference to recognized authorities, to satisfy himself that the suggestions made are substantially justified by facts. [A. C. DOBBS.]

THE BEST FIELD METHOD FOR SOWING COTTON.

THE note by Mr. Sawhney[1] in the January 1925 issue of this Review has reminded me of my own experiences in collaboration with Mr. F. S. Holton in 1912-13, when we broke some records for rate of seed propagation. No detailed account of our technique has been published, but it may be summarized thus: We produced as many seeds as we could from each plant (by wide spacing), and then raised as many single plants as we could from the available seed, by "sand sowing."

The present note deals with this sand-sowing technique, the effects of spacing having been fully described by us previously, though from a different angle.[2] The actual practical result of this dual method should first be noted, however; it was this, that in three separate cases we produced a *ton* of ginned seed in the 1913 harvest grown from the offspring of *one seed* sown in 1911. Moreover, this was done under most difficult conditions of extemporization, so that a great increase in these figures is easily practicable.[3] If "practical men" would realize the possibilities that await the adventurer who, for a special purpose, will break away from practice, our control of seed supplies might be very much improved, and the plant breeder's skill would be more effectually utilized.

Mr. Sawhney has the credit of being the first to call attention to the advantages of plain sand as a seed-bed for cotton, but his method does not go so far as it can be pushed. As described by him it is a "garden" technique, the seedlings being washed out and transplanted. But it is easier, quicker, cheaper, and safer to make the sand seed-bed out in the field where the adult plant is to stand, and still obtain such remarkable efficiency as was shown by our statistics, *viz.*, 70 to 90 per cent. of adult successes on a twenty-acre field when only single seeds were sown.

In my earlier cotton-breeding researches I had tried various approved methods for economizing seed, to mitigate the feeble-mindedness of the infant cotton plant. The farmer's method of sowing eight to twenty seeds per hole and thinning to two

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[1] Sawhney, K. *Empire Cotton Growing Review*, Vol. II., 1925, p. 42.
[2] Balls, W. L., and Holton, F. S. *Phil. Trans. Roy. Soc.*, B, Vol. 206, pp. 103, 180.
[3] See *Report of Imperial Botanical Conference*, 1924, p. 84.

seedlings is useless when seed economy is all-important. As it is imperative to provide some kind of soil-breaker, I tried—and rejected—an American dodge of using beans; they merely burrow out, without lifting the clods of soil. Then a better plant was tried—*viz.*, Bamia (or Okra, *Hibiscus esculentus*)—and in special cases cotton itself, utilizing the Red-leaf Uplands. With Bamia or Red-leaf it was possible to sow single pedigree seeds, but the thinning process was tedious. Too much risk was run by the single pedigree seedling if its neighbours were roughly uprooted, and it was also liable to be "drawn" if thinning were at all delayed; cutting out with scissors was eventually practised, but besides being slow and tiring, it left rotting roots in the ground.

Finally, stimulated by emergency in the shape of a plague of mole-crickets (which left us with only 2 lb. of seed and fifteen wide-sown acres to replant), we devised the sand-sowing method. We afterwards learned that it is current practice with the native cultivators in Tokar, though in a cruder form. It was subsequently adopted by Mr. H. C. Jefferys for propagation work on the State Domains, with a seed-rate of, I believe, three seeds per hole. My present purpose is to describe our technique as used, successfully, for the ideal seed-rate of one seed per hole; and in particular I wish to emphasize the point that this limit of refinement can be reached with very little trouble and at a trifling cost.

Equipment. 1. Cotton seed, preferably soaked and just starting to crack.

2. Any receptacle with a sling handle, holding a pint or so of fine sand, sifted through a 144-mesh or finer.

3. A large teaspoon, or similar ladle, for handling the sand.

2 *and* 3. *Alternatively*, an arrangement like the old muzzle-loader powder flash would be excellent, delivering a small fixed quantity of sand.

4. A round wooden dibble, the size of a pencil, *i.e.*, just thick enough to make a hole into which one seed will drop freely. A wire nail driven through it sideways, at 1 inch from the end, defines the depth of the hole it makes.

5. A hoe.

6. On special occasions only— a fountain-pen pipette in a receptacle like (2), but holding water.

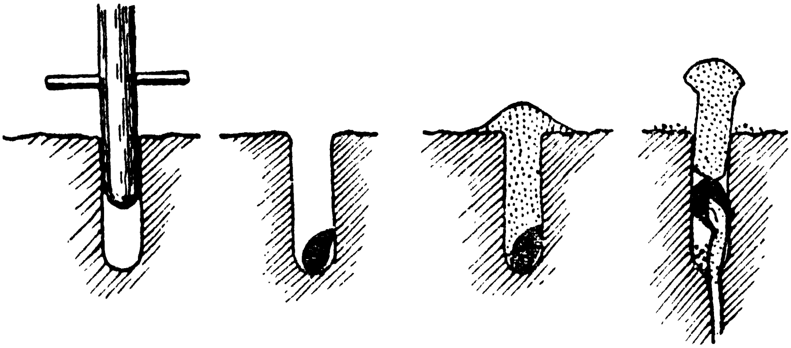
Method. Sowing is best done in wet soil, which will not need further irrigation or rain. For ordinary sowing in Egypt the work is done by pairs, a man opening the holes with a hoe, and a child following to drop and cover the seed. The present method is carried out most quickly by gangs of three, thus:

The leader, who carries the hoe, pulverizes and consolidates for a hand's-breadth the soil where each plant is to stand, in order to increase the subsequent upflow of soil water and make a good seed-bed.

The second of the gang, carrying dibble and seed, dibbles the 1 by $\frac{1}{4}$ inch hole in this prepared soil, drops one seed to the bottom of the hole, and cleans the dibble.

The third ladles a spoonful of sand into the hole, having previously squirted a pipette of water upon the seed if the soil is on the dry side.

When first we tried this method we found the subsequent procedure of the cotton plant rather unexpected. The seedling rarely breaks the plug of sand, which is usually simply lifted like a cork coming out. Finally, the plug falls over and breaks, and the seed leaves unfold through its debris. The diagrams are self-explanatory.



Sowing single seeds.

Details. Size of dibble will, of course, vary with the size of the seed, and ranges from $\frac{1}{4}$ by $\frac{1}{2}$ inch with some Indian cottons to $\frac{1}{2}$ by $1\frac{1}{2}$ inches with some fuzzy Uplands. The fit should always be as close as is practicable. A pint or so of sand, or of water, will evidently be sufficient for 200 to 800 holes, so that replenishments do not call for elaborate transport arrangements. Dibbles can be made by the score in an hour, and old jam-pots with a loop of string are not expensive. Under labour costs we have to reckon for one extra child, plus the fact that the gang of three will be well advised to progress rather more slowly than the usual gang of two; for the operation, though simple, is worth a little extra care. To credit we may set the value of some seed economized, *i.e.*, 90 per cent. of the usual cost of seed.

However, my purpose is not to advocate the everyday use of this method, for seed is cheap; though where maximum acreage is desired from a limited stock of seed the method can be worked commercially. My wish is to show that the sand-sowing method can be taken out into the field, carried to any degree of refinement up to the limit of one seed per hole, and used as easily and successfully on hundreds of acres as on a small plot. Lastly, if it may seem a small thing to raise ten separate plants instead of two half-plants from twelve seeds, the reader has probably forgotten that each year multiplies the effect, so that after two years the difference is not 10 : 1 but 100 : 1, and has become a million to one after only six years. Since this is only half the control we can exert on seed propagation (spacing giving the other half), there is no reason why we should go slowly, following in the footsteps of the farmer who must set his pace entirely by considerations of profit and loss. [W. Lawrence Balls in *Empire Cotton Growing Review*, II, No. 3.]

REGULATIONS FOR IMPORT OF AMERICAN COTTON INTO BRITISH INDIA.

In exercise of the powers conferred by sub-section (1), section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), hereinafter referred to as the said Act, the Governor-General in Council is pleased to issue the following order for the purpose of regulating the import into British India of American cotton :—

1. In this order—

(i) "Cotton" includes all ginned cotton, whether baled or loose, but does not include cotton seed or unginned cotton.

(ii) "American cotton" means all cotton produced in any part of America.

2. On or after the 1st December, 1925, American cotton shall not be imported into British India by means of the letter or sample post and shall not be imported by any other means save through the port of Bombay between the first November and the thirty-first of May in any year and subject to the following conditions :—

(*a*) On or before the departure of a ship carrying a consignment of American cotton for Bombay from the port from which the cotton is consigned, the consignee shall ascertain the name of the ship, the probable date of its arrival in Bombay and the number of bales of American cotton contained in the consignment, and shall furnish this information to the Collector of Customs, Bombay, not less than three weeks before the arrival of the ship at Bombay; provided that where the cotton is loaded for Bombay at Port Said or at a European port, the ordinary length of voyage from which is less than three weeks, it shall be sufficient to furnish the information not less than 10 days before the arrival of the ship.

(*b*) On arrival at Bombay, the cotton shall be disinfected in such manner as shall be prescribed in rules made by the Government of Bombay under section 5 of the said Act.

(*c*) Prior to landing the cotton the importer shall pay or agree to pay a sum at a rate fixed by the Governor-General in Council sufficient to cover the cost of fumigation.

THE PUSA SCIENTIFIC ASSOCIATION.

We have received the following for publication :—

The Pusa Scientific Association was started in October 1924, under the patronage of Dr. D. Clouston, C.I.E., Agricultural Adviser to the Government of India, to afford a meeting ground to the staff of the Institute, for the discussion of problems bearing on agriculture and its allied sciences. During the first year of its existence

12 papers of scientific interest were read ; they were followed by animated discussions in which many members took part.

The subject of the first paper read on 28th November, 1924, was *The Indian Sugarcane Industry*, in which Rao Saheb Kasanji D. Naik ascribed India's dependence on foreign countries for her sugar supplies to the low yields of the canes grown and wasteful methods of manufacture. In view of the enormous area under sugarcane, in his opinion a slight increase in the yield per acre would go a great way in enabling India to produce all the sugar required for local consumption. Thanks to the Imperial Cane-breeding Station at Coimbatore, improved canes of heavy yielding, early-ripening and drought-resisting qualities were now available. Efforts for the improvement of the sugarcane industry should be directed towards the spread of such improved varieties, the adoption of better cultural and manurial methods and the promotion of the efficiency of sugar factories.

On 19th December, 1924, Mr. K. K. Guha Roy read a paper on *Libraries and Library Methods*. Of the several methods of classification in vogue, the speaker considered the subject classification of Brown as the most suitable for libraries used by research workers.

Some Aspects of Green-manuring was the subject of a lecture by Mr. N. V. Joshi on 23rd January, 1925. Basing his opinion on experiments carried out at Pusa, the lecturer said that the same crop of sann-hemp could be economically used for the double purpose of green-manuring and fibre production by ploughing in only the tops and retting the stems.

On 26th February, the Medical Officer of the station (Mr. D. F. Michael) spoke on *Our Habits and Health*. He suggested the giving up of several old habits and adoption of certain new ones for maintaining a healthy and vigorous life. *Organotherapy* formed the subject of another discourse by Mr. Michael on 26th June.

In a paper read on 27th March, Mr. A. T. Sen dwelt on the *Various uses of X-Rays* in different branches of human activity.

On 28th April, Mr. P. B. Sanyal read a paper on *Sugar-beet and its possibilities in India*. The reader suggested that Bihar offered special advantages for the cultivation of sugar-beet. Experiments at Pusa indicated the possibilities of having supplies of good quality roots from the middle of March to the middle of May. Sugar-beet cultivation would therefore, if adopted, extend the working season of sugar factories operating in Bihar by at least two months.

In his paper on the *Theory of Evolution and its Pioneers*, read on 29th May, Mr. N. L. Dutta dwelt specially on the evolution of plants.

On August 4, Mr. J. N. Mukerji spoke on the *Indian Tobacco Industry*. He observed that although India stood second among tobacco-producing countries of the world, the quality of the local product was poor and its market price low. Among the improvements suggested by him, were (1) the introduction of superior varieties by acclimatization and hybridization, (2) modification of environment, *e.g.*, soil, climate, fertilizer, etc., and (3) adoption of up-to-date methods of curing.

Crop Rotation formed the subject of the paper read on August 27th. Mr. R. P. Chauhan remarked that the object of crop rotation was to increase the productiveness of various crops by conserving the fertility of the soil and eliminating weeds, pests and crop diseases. He gave some rotation schemes for a two and three year course.

The subject before the meeting held on September 17 was *Vitamin and its present Position.* Mr. S. Das held that with milk as the nucleus of the diet containing all the vitamins, fresh vegetables, fruit and cereals could constitute a complete diet, provided one took enough to assure all calorific requirements. He concluded by saying that the discovery of vitamins had for the first time rendered possible a rational system of dietetics.

In the last ordinary meeting held on 13th November Mr. C. S. Rama Ayyar read a paper on *Micro-organisms in relation to Industries.* He gave an account of the work done at Pusa to improve the saltpetre and the natural indigo industries and to reduce the loss of cane sugar by inversion in sugar factories, in all of which micro-organisms played an important rôle. The activated sludge process of sewage treatment, manufacture of dairy products, retting of flax and hemp, preparation of ensilage, curing of tobacco, etc., were mentioned as subjects affording great scope for improvement by detailed work on the various microbes concerned.

In addition to these 12 ordinary meetings, a special meeting under the auspices of the Association was held on 9th January, when Mr. A. C. Chakravarty, who has recently returned from America with training in engineering, gave a discourse on *Village Reconstruction* with particular reference to the work being done by himself in the Rajshahi District of Bengal.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

The title of Rai Sahib has been conferred on Babu Debendra Nath Mitra, District Agricultural Officer, Faridpur, and Babu Sharat Chandra Pal, Assistant Director, Civil Veterinary Department, Bengal, and that of Rao Sahib on Mr. V. P. Subramanya Mudaliyar, Deputy Superintendent (retired), Civil Veterinary Department, Madras.

MR. J. T. EDWARDS, B.Sc., M.R.C.V.S., Director, Imperial Institute of Veterinary Research, Muktesar, has been granted leave on average pay for eight months from 1st March, 1926.

MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist, Pusa, has been granted leave on average pay for seven months from 15th March, 1926.

MR. WYNNE SAYER, B.A., Secretary, Sugar Bureau, Pusa, has been granted leave for six months and 15 days from 25th March, 1926. Rao Saheb Kasanji D. Naik will hold charge of the current duties of the Secretary, Sugar Bureau.

MR. JATINDRA NATH SEN, M.A., Ph.D., Supernumerary Agricultural Chemist, Pusa, on deputation, has been appointed Biochemist at the Forest Research Institute and College, Dehra Dun, from 4th February, 1926.

MR. ZAL R. KOTHAWALA, B.Ag., B.Sc., N.D.D., has been appointed Assistant to the Imperial Dairy Expert with effect from 30th November, 1925.

MR. K. MCLEAN, B.Sc., Assistant Director of Agriculture, Bengal, has been allowed leave on average pay for eight months from 23rd February, 1926.

MR. PROVAT CHANDRA CHAUDHURI has been confirmed in his appointment of Deputy Director of Sericulture, Bengal, in the Indian Agricultural Service, from 17th October, 1922.

MR. R. O. ILIFFE has been appointed Paddy Specialist in the Department of Agriculture, Madras, temporarily for a period of five years from 27th November, 1925.

MR. C. G. PARANJPYE has been appointed to act as Agricultural Engineer to Government, Bombay, *vice* MR. W. M. Schutte on deputation.

MR. G. CLARKE, F.I.C., officiating Director of Agriculture, United Provinces, has been confirmed in that appointment with effect from 22nd December, 1925.

MR. H. COPLEY, Agricultural Engineer, Central Provinces, has been granted combined leave for one year with effect from 17th December, 1925.

MR. R. WATSON, N.D.A., Deputy Director of Agriculture, Burma, has been placed on special duty to carry out a coconut survey in the Irrawaddy Division.

CAPTAIN J. B. IDLE, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, has been confirmed in his appointment in the Indian Veterinary Service with effect from 4th December, 1925, and has been placed in charge of the Central Circle (Meiktila) and of the stock-breeding farm at Tatkon.

CAPTAIN S. R. RIPPON, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, has been placed in charge of the Insein Veterinary School and of the South-Western (Bassein) and South-Eastern (Moulmein) Circles and also of the Arakan Sub-Circle (Akyab).

REVIEW

The Land and the Nation.—RURAL REPORT OF THE LIBERAL LAND COMMITTEE, 1923-25. London: Hodder and Stoughton. Price, 1*s.* net.

The report is concerned with the investigation of the land problem in Great Britain to-day. It contains a mass of detailed information, the result of extensive enquiry both in Great Britain and abroad. Further, the report is very readable. It contains 584 pages, appendices, 11 chapters and 4 main parts. Parts I—III are concerned with the investigation of the land problem; Part IV is a statement of the policy proposed, together with an examination of alternative proposals.

In a comparison of rural life and industrialism as they exist in Great Britain, we find "that out of a total population in England and Wales of less than 38 million persons more than 30 millions, *i.e.*, just over 80 per cent. live in urban districts" (Census of 1921); "that only 7·2 per cent. of our occupied population was in 1921 dependent on agriculture"; "that the number of persons now registered as out of work (1,343,700—August 1925) is larger than the total number of persons engaged in agriculture in the whole of Great Britain (1,254,349—Census 1921)"; "that our towns contain more people than they can employ, and that our fields employ fewer persons in proportion to their area than the fields of any country whose civilization is reasonably comparable to our own."

In Chapter III—Food, Land and People—we are startled to read that "in 1914 the gross production from British land was practically the same as it was in 1814 and much less than it was in 1840."[1] A cause for our failure in agricultural production seems to be in our pursuit of industrialism and the ignoring of agriculture in its days of depression—some 40 years ago. A comparison with continental countries illustrates this. Take Denmark. "When she (Denmark) no less than Great Britain was exposed to heavy imports of cheap wheat from the virgin prairie land of America, she accepted the importation of cheap wheat and extracted from it the maximum of advantage. Instead of attempting to compete in corn growing with America, either with or without Protection, she built up a system of arable farming for stock, making use of any cheap imports which might be used for fodder .... In Great Britain cheap wheat, though a boon to the urban population, was to farmers a disaster...... In natural consequence the area under wheat has for the last 40 years steadily declined." Regarding wheat imports we may note that of bread eaten in Great Britain 80 per cent. is made of flour imported either as such or as grain. In the matter of animal husbandry, referred to above, if we compare England with Denmark, Holland and Belgium in the number of

[1] *The Land and its Problem*, by Christopher Turner; quoted in the Report.

live-stock units--cattle, sheep and pigs—per 100 acres of land, we find, in the last 40 years or so, in England an inclination to decline from 30 units per 100 acres, while in the other three countries there is a very noticeable tendency to increase from below 30 units per 100 acres to 39 and upwards.

Area statistics for Great Britain show that "2-5ths of unbuilt of land is either mountain, moor or downland, or is used only for rough grazing or not at all....... There has been a shrinkage in the total of cultivated land, of arable land, of corn land, of the area of roots and green crops and of the number of live-stock per hundred acres." "In 50 years over 4 million acres of British soil have been lost to the plough."

"The diminishing importance of agriculture in relation to other industries is illustrated by the fact that the persons occupied in agriculture were in 1921 7·2 per cent. of the total population." While the figure for Denmark in 1921 was 33 per cent., for France in 1911 40·7 per cent.

The report gives a typical minimum wage table for an adult male agricultural worker, and adds the comment "that an agricultural labourer of......would be better able to support his family if dependent on the Poor Law than when in receipt of the statutory wages for a full week's work," and "that the lowest agricultural wage in an English county is identical with the unemployment benefit for a man with the 'standard' family."

Chapter IV deals chiefly with farming—production and cost—and the relationship between farmer, land and labourer. It shows "that a great deal of farming in England is far less productive than it need be"; "that we could undoubtedly produce much more before we reach the point at which extra effort becomes uneconomic," and this particularly by small men. To quote Sir Daniel Hall,[1] "We possess farmers full of enterprise, none better; but their example is not generally followed, their methods have not been systematized so as to become the ordinary standard of agriculture. Many farmers are short of capital for the size of their holdings and they cannot, if they could, depart from the routine of minimum of cultivation; still more are knowledge, determination and enterprise lacking." [2]"This shortage of capital is reflected by economies in labour.." Again, "what above all is lacking in England is not so much an agricultural atmosphere....as a peasant atmosphere....In England of to-day the country is the place where one goes to spend the money earned in the towns. In France the position is exactly reversed. The habit of indulging in land-owning at a loss is one of the factors mainly responsible for queering the pitch of English agricultural production"[3]; and "it is in the interests of the efficiency of farming as a whole that qualified labourers should be enabled to start on their own account and to rise into the ranks of farmers." Thus stemming the rural exodus and providing access to the land.

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[1] *Pilgrimage of British Farming.*
[2] Quoted in the Report.
[3] *L'angleterre d'Anjourdhui.* Par. Siegfied.

Chapters V and VI are devoted to a survey of agriculture, tenure and landlordism. The argument is that "landowners being unable to develop the true values of their estates tend to develop false values, to the detriment of output; for high amenity values make for low agricultural returns. The business side of farming is not attended to, for leadership is lacking," "the landlord's position in agriculture is not one of privilege but of utility"; "the right of ownership of land rests on nothing but the performance of a useful function," and one of the chief functions it would appear is to supply permanent capital. The trouble is as pointed out in the report the uneconomic position of the landlords. "Mr. Turner in 'The Land and its Problem' says that examination of the account books of typical estates shows that after paying taxes, rates and the cost of upkeep of farms, houses, buildings, the landowner is left with only 3*s*.9*d*. in the £ as effective income, and often much less."[1] Further figures for ten representative and rural estates in different parts of the country "show the net rent as a percentage of the gross rent on an average figure to be 61·8 per cent."[1] Other examples may be quoted with a less happy result, indicating the tendency of incomes on estates in Great Britain.

A survey of the position of landlordism since 1913 brings forth the following statement from the Committee: "It is not a question of assisting landlords to justify their ownership of agricultural land. It is a question of finding the right system of land tenure to replace landlordism."

Chapter VII defines and discusses the policy proposed. The policy advocated is one of cultivating tenure. The present landlord-tenant system is to go. The landlord is to be bought out; the State is to resume its overlordship of land, and shall "transfer all the tenant-held land to the present cultivators, whenever they are good cultivators. The landlords shall be paid an annuity equivalent to the net rent which a good landlord would be making out of the land. The landlord will also receive the present building value of his land as it is realized. The farmer will pay the equivalent of his present gross rent less the amount properly chargeable for repairs, maintenance, management and tithe. The good farmer will have absolute security of tenure, at a fixed annuity, which he may devise on death to his descendants. He will be required to carry out all repairs and maintenance himself, and as he is the one man interested it is confidently believed that he will carry them out. The bad farmer, after opportunity of amendment, will be turned out. The functions of estate management, which are at present exercised by landlords, will be carried out by county agricultural authorities, representative of agricultural interests in each district."[2]

Chapter X contains alternative proposals put forward by others and considered and criticized by the Committee. There are two: both modifications of the landlord-tenant system. The one is the small holding system. Here the rent is fixed

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[1] Quoted in the appendices to the Report.

[2] "The New-Land Reform Proposals" by the Rt. Hon'ble F. D. Acland in *The Contemporary Review* (November, 1925) where the policy is well summarized.

by a public body and the tenant may devise to members of his family. The other the Evesham custom. " This is a custom which has grown up in the fruit-growing district round Evesham by which the departing tenant finds his own successor—someone, that is, who is prepared to purchase the value of his tenant right....." These systems presume that the landlord will meet all necessary capital charges, and " it would leave the landlord in the industry as a rent charging sinecurist. It would do nothing to safeguard the nation's right to assist a good cultivation, and nothing to remedy the landlessness of the labourer."

Chapter XI evokes a note of energy and hope. As has been mentioned above, the report is very readable; but one cannot conclude it without being reminded of the gravity of the agrarian conditions as they exist in Great Britain to-day. [J. C. W.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Farm Implements and Machinery, by J. R. Bond. Pp. 298. (London : Ernest Benn, Ltd.) Price, 18*s*. 6*d*.
2. Your Few Acres : How to manage them for profitable production, by E. T. Brown. Pp. xiii+254. (London : Chapman & Hall.) Price, 10*s*. 6*d*.
3. Farming Records and Accounts, by E. E. Spicer and E. C. Pegler. Pp. 140. (London : H. E. L. (Publishers), Ltd.) Price, 10*s*. 6*d*. net.
4. Outlines of Agricultural Economics, by Henry C. Taylor. Pp. xii+610. (New York : The Macmillan Co.) Price, 14*s*. net.
5. Agricultural Co-operation in the British Empire—with an introduction by Sir Horace Plunkett. Pp. 254. (London : Geo. Routledge.) Price, 10*s*. 6*d*. net.
6. Principles and Practice of Farm Book-keeping : A Text-book for Agricultural Students. Pp. 484. (London : Gee & Co.) Price, 15*s*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Determination of Available Phosphoric Acid of Calcareous Soils, by Surendralal Das, M.Sc. (Chemical Series, Vol. VIII, No. 6.) Price, As. 12 or 1*s*. 3*d*.
2. Deterioration of Sugarcane during its Storage by Windrowing, by Phani Bhusan Sanyal, M.Sc. (Chemical Series, Vol. VIII, No. 7.) Price, As. 6 or 8*d*.

Bulletins.

3. Bot Flies of the Punjab, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. (Pusa Bulletin No. 160.) Price, As. 14 or 1*s*. 6*d*.
4. Tentative Keys to the Orders and Families of Indian Insects, by T. Bainbrigge Fletcher, R. N., F.L.S., F.E.S., F.Z.S. (Pusa Bulletin No. 162.) Price, R. 1-4 or 2*s*. 3*d*.

Miscellaneous.

5. Catalogue of Indian Insects. Part 10—Stephanidæ, by G. R. Dutt, B.A. Price, As. 5 or 6*d*.

EDITORIAL

THE CATTLE CONFERENCE.

THE agenda for discussion at the fourteenth meeting of the Board of Agriculture in India, held at Pusa in December 1925, contained the following six important subjects dealing with animal husbandry and the dairying industry in India :—

(*a*) To review the progress made by the Central and Provincial Governments and by Indian States since the last meeting of the Board of Agriculture in developing animal husbandry and dairying, and to make recommendations.

(*b*) To review the results obtained and experience gained in making silage in India, and to make recommendations.

(*c*) To consider to what extent Provincial Governments and Indian States can co-operate with the Central Cattle Bureau in the formation of pedigree herds of Indian cattle and in the control of pedigree records.

(*d*) To consider the extent to which Co-operative Departments can co-operate with Agricultural and Veterinary Departments in the development of cattle-breeding and dairying.

(*e*) To consider what further steps can now be taken by Government to combat outbreaks of cattle disease, and particularly to set up a permanent immunity against rinderpest amongst susceptible animals by the application of the serum-simultaneous method of preventive inoculation.

(*f*) To consider whether the time has now come for Provincial Governments and Indian States to train men for the Indian Dairy Diploma of the Imperial Institute of Animal Husbandry and Dairying.

These six subjects were referred by the Board to a Cattle Conference, under the chairmanship of Dr. D. Clouston, C.I.E., Agricultural Adviser to the Government of India and President of the Board. The Conference was very representative in its personnel, which consisted of delegates from the Imperial Department of Agriculture, the Agricultural, Veterinary and Co-operative Departments of the provinces of British India and the leading Indian States, the Military Dairy Farms Department, and private institutions connected with the cattle-breeding and dairying industries. The Conference submitted reports and made recommendations which were subsequently placed before the full meeting of the Board.

In his introductory speech to the Board, Dr. Clouston, Agricultural Adviser to the Government of India, referred to the subjects on the agenda dealing with animal husbandry and dairying, and emphasized the importance of cattle improvement to the advancement of Indian agriculture. He mentioned the work which was being done in this direction by the Imperial and Provincial Departments of Agriculture and by the more advanced Indian States, and informed the Board that the Government of India had decided to establish a Central Bureau of Animal Husbandry to stimulate and co-ordinate these efforts. Dr. Clouston pointed out the urgent need for the extension and improvement of fodder supply as a preliminary to more widespread improvement of cattle, and indicated the value of silos and silage-making in increasing the fodder resources of the Indian cattle-owner and breeder. He invited the attention of the Board to the necessity for increased facilities for scientific and practical education in cattle-breeding and dairying, and to the possibility of the wider use of co-operative organization in solving the problems of animal husbandry. Last but not least, careful consideration must be given to the extended introduction of the latest preventive measures for the protection of Indian herds against outbreaks of cattle diseases, in particular, rinderpest.

The Hon'ble Khan Bahadur Sir Muhammad Habibullah Sahib Bahadur, K.C.I.E., Kt., Member of His Excellency the Viceroy's Executive Council, Department of Education, Health and Lands, said, in the course of his speech opening the Board, that the Government of India had taken over three dairy farms at Wellington, Karnal and Bangalore and also the military creamery at Anand for training and research purposes. Particular attention was also being given to the claims of agricultural education, especially with regard to veterinary training, animal husbandry and dairying. He paid a tribute to the work done by the Imperial and Provincial Governments in cattle improvement and protection against diseases as well as in the general agricultural development of the country, and concluded an inspiring speech with an appeal for co-operation for further progress between the big landowners of India and the Government departments directly concerned in the advancement of Indian agriculture and the improvement of rural conditions.

The Cattle Conference met on the second and third days of the Board meeting, and discussed the subjects which had been referred to it for report. The full reports of the Conference are to be found in the published proceedings of the Board, and are therefore not included in the following review of the Conference meetings.

Subject (a)—To review the progress made by the Central and Provincial Governments and by Indian States since the last meeting of the Board of Agriculture in developing animal husbandry and dairying, and to make recommendations.

The Chairman, Dr. Clouston, gave a resumé of the action which had been taken on previous recommendations of the Board of Agriculture in connection with the cattle and dairying industries. Members of the Conference representing the Central and Provincial Governments and Indian States gave detailed accounts of the progress

which had been made in animal husbandry and dairying in their respective territories since the last Board meeting in 1924. The Imperial Agriculturist asked members of the Conference to make a personal inspection of the work done at Pusa, and the Imperial Dairy Expert issued a similar invitation with regard to the Institute and farms under his control. In almost every province and State, marked progress was recorded, and the Conference showed much interest in further proposals for extending the work of cattle improvement in the Punjab and Madras. Appreciative note was taken of the action of the Bombay and the Bihar and Orissa Governments in appointing Cattle Committees to consider the improvement of live-stock in these provinces, and an extension of this policy was advocated. In Baroda, a similar Committee has been formed and its recommendations are awaited. The Director of Farms, Simla, gave a most interesting account of the cross-breeding work for milk production carried on by the Military Dairy Farms Department. He stated that the extension of crossing to $\frac{3}{4}$ and $\frac{7}{8}$ European animals had not proved successful, and that the policy now adopted in his farms was to cross the half-bred cows with the best Indian bulls available. In supporting this policy, the Assistant Director of Farms, Jubbulpore, put some interesting information with regard to Friesian crosses before the Conference. In the course of the discussion, it became evident that the Agricultural and Veterinary Departments in many provinces had achieved successful co-operation with local non-official agencies in the work of cattle improvement. Various methods of propaganda work in the direction of improved animal husbandry and dairying were considered. The successful experience of the Imperial Dairy Expert in using the cinema for publicity purposes was brought to the notice of the Conference. Many Indian States encourage the improvement of live-stock by granting subsidies, prizes and awards to successful and scientific breeders. At the conclusion of the discussion, the Conference heard Mr. Collins on the proposed Bihar and Orissa Cattle Bill, a measure introduced by a private member of the Legislative Council of that province to remedy existing defects in legislation concerning protection of cattle and measures for cattle-breeding. The proposed Bill was generally approved by members of the Conference, and it was agreed that copies of the draft be circulated along with the proceedings of the Board.

Subject (b)—To review the results obtained and experience gained in making silage in India, and to make recommendations.

The Chairman invited members of the Conference to give their experiences in silage-making and to express their views on the subject under discussion. The general opinion of the speakers was that the "pit" form of silo gave better results and occasioned less wastage than the "tower" types. The military representatives on the Conference stated that silage-making was essential to the economic working of the military dairy farms. This view was corroborated by the Imperial Agriculturist, who described the work of silage-making at Pusa and emphasized the superiority of maize silage. The Imperial Dairy Expert gave some valuable evidence on the keeping properties of silage, even under adverse conditions, and termed

the practice of silage-making " the sheet anchor of the dairying industry in India." Representatives of the provinces and Indian States told the Conference what work had been done in their areas in the construction of silos and in silage manufacture. Mr. Warth, Physiological Chemist, Bangalore, drew attention to the valuable work done by Dr. Lander on the chemistry of silage-making, and suggested that many unpalatable, or even prejudicial, substances might be converted into useful cattle foods by the agency of ensilage. Some discussion took place on the best methods of demonstrating the possibilities of silo construction and silage manufacture to the cultivators in order to induce them to adopt this system of increasing their fodder resources. In addition, the Conference collected information on various materials used for silage manufacture in different parts of India.

Subject (c)- To consider to what extent Provincial Governments and Indian States can co-operate with the Central Cattle Bureau in the formation of pedigree herds of Indian cattle and in the control of pedigree records.

The Chairman read out to the Conference the resolution passed at the Board of Agriculture in India, 1924, recommending the establishment of a Central Bureau of Animal Husbandry at Pusa, and defined the main functions of that Bureau. The Imperial Dairy Expert emphasized the importance of this subject and the necessity for the co-operation of all Provincial Governments and Indian States in the working of the Bureau. He instanced the peculiar difficulties which would be encountered in forming and maintaining herd books, pedigree records and milk records in India. The system of registration adopted in the case of the pure Sahiwal herds of the Military Dairy Department was described to the Conference. Mr. Forman, of the Allahabad Agricultural Institute, outlined the system of co-operative cow-testing associations in America, and suggested that preliminary work of a similar nature might be started in India. Finally, the Conference adopted the proposal that this subject should be considered in the first place by a small Sub-Committee, which should report to the Conference.

Subject (d)—To consider the extent to which Co-operative Departments can co-operate with Agricultural and Veterinary Departments in the development of cattle-breeding and dairying.

Mr. Calvert, I.C.S., Commissioner, Rawalpindi Division, stated that the Co-operative Department was really one of adult education. He showed how the Co-operative Department in the Punjab assisted the Agricultural and Veterinary Departments in their propaganda work, and how considerable progress was resulting from such co-operation. The Imperial Dairy Expert laid stress on the advantages of co-operative dairies, and quoted the achievements of Denmark in this connection and the beneficial effects of co-operation on the improvement of cattle in that country. Several members introduced the question of the duty of Government in assisting co-operative enterprise, especially in its initial stages and, particularly, in the provision of efficient supervision and management. An

account was given of the success which has attended co-operative milk societies outside Calcutta. The importance of co-operative organization, not only on behalf of producers, but also of consumers, was brought before the Conference, and some discussion on the practicability of forming successful consumers' societies ensued. It was agreed that co-operative fodder storage societies, especially in famine areas, were desirable, and the activities of the Bombay Government in this connection were brought to the notice of the Conference. The discussion on this subject, though unanimous on the value of co-operative organization in the cattle-breeding and dairying industries, revealed considerable divergence of opinion on the most suitable nature of such organization in India and on the ways and means of its development and extension.

Subject (e)—To consider what further steps can now be taken by Government to combat outbreaks of cattle disease, and particularly to set up a permanent immunity against rinderpest amongst susceptible animals by the application of the serum-simultaneous method of preventive inoculation.

The veterinary members of the Conference submitted a note on the subject under discussion and on the work which had been already done in controlling outbreaks of cattle diseases. The experience with serum-simultaneous inoculation against rinderpest on the military dairy farms was recounted and satisfaction expressed at the results achieved. Some discussion took place on the reported deaths from rinderpest of animals previously inoculated by the serum-simultaneous method, but the bulk of the evidence showed that such cases could almost invariably be traced to neglect of essential precautions during inoculation or to secondary infections. The Director, Civil Veterinary Department, Bihar and Orissa, appealed for further investigation into the commoner cattle diseases of India, and advocated the establishment of research centres, on a sound financial basis, in the different tracts of the country where these diseases were prevalent. The necessity for controlling the movements of cattle in disease-affected areas also received the consideration of the Conference.

Subject (f)—To consider whether the time has now come for Provincial Governments and Indian States to train men for the Indian Dairy Diploma of the Imperial Institute of Animal Husbandry and Dairying.

The Imperial Dairy Expert, in introducing the subject, emphasized the essentially practical nature of the training for the Indian Dairy Diploma, and stated that the present facilities for students were quite inadequate to meet the demand throughout India. He pointed out the advantages which would accrue from extension of training for the diploma in the provinces and Indian States and the necessity for special instruction to meet local requirements. The facilities at present available for advanced practical training in scientific dairying were not being utilized to the full, and Provincial Governments and Indian States should consider to what extent they could further develop this important branch of agricultural education. The

Conference expressed general agreement that increased facilities for training men for the Indian Dairy Diploma were necessary, but, in certain cases, difficulties in obtaining the finance necessary to reach the standard of training required, were put forward. The Imperial Dairy Expert did not think that such difficulties were insuperable, and said that no reduction in the standard of training could be contemplated. He would welcome the co-operation of provinces and States in this matter and would assist them in framing suitable schemes.

W. J. JENKINS.

ORIGINAL ARTICLES

AGRICULTURE AND SCIENCE*

BY

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The application of science to agriculture is a comparatively modern development. Since 1834, when Boussingault laid the foundations of agricultural chemistry, an increased and increasing amount of attention has been devoted to agriculture by men of science. I propose briefly to recapitulate some of the more important advances which have resulted from this impact of organized knowledge on the most ancient of the arts, and then to deal in greater detail with some of the agricultural problems of to-day in the solution of which science is certain to play an important part. In reviewing the development of agricultural science, two things must be kept in view—the influence of science on practice and, what is perhaps more interesting, the lessons which agriculture has taught and is still teaching the scientific investigator. I hope to show that the great benefits that have flowed from the application of science to practice are not always on the side of agriculture, but that scientific method itself has sometimes profited from the association. Further, the man of science has had to realize that progress is possible without the aid of science, and that some of the greatest developments in agriculture, even at the present day, have been brought about by empirical means.

Examples of notable advances in agriculture which have taken place without the aid of science are to be found all over the world. In the Orient, perhaps the most remarkable is the cultivation of rice which has been developed by the people in the deltas of the great rivers to a high degree of perfection and carried up the slopes of valleys by means of a system of irrigated terraces. The care and skill which have enabled the cultivator to grow a semi-aquatic crop like rice on the steep hill sides of India and Ceylon cannot fail to command our attention and respect. In this development, science has played no part and even now has not completed the preliminary analysis of the factors involved in the growth of the chief cereal of the tropics. We can only guess at the sources of the nitrogen made use of by the rice plant. Again

* Presidential Address to the Thirteenth Indian Science Congress, Bombay, January 1926.

in Gujarat in the Bombay Presidency, an indigenous system of agriculture has been evolved to overcome a most difficult set of soil and moisture conditions. In order that the tilth may be maintained and the moisture conserved speed is essential in managing these soils. To get over the fields quickly, the crops are grown in straight lines; simple but effective implements have been designed for sowing and inter-culture and a fast and powerful breed of oxen has been developed. The adaptation of means to end is remarkable and great natural obstacles have been overcome by the peasantry unaided. In the Occident, equally striking advances have been made by empirical means. Sub-soil drainage, the modern systems of tillage, the great progress which has been made in the breeding of live stock, the Norfolk four-course system of rotation—which followed the introduction of the turnip crop into Great Britain in 1730—are all improvements which owe nothing to the scientific investigator.

The early pioneers of agricultural science were chemists. A French chemist laid the foundation stone in 1834. Liebig's classical monograph on agricultural chemistry appeared in 1840 which instantly attracted the attention of agriculturists who, for the first time, were made acquainted with the help they were likely to obtain from the application of chemistry to the tillage of the soil. Three years later—in 1843—the Rothamsted Experiment Station was founded by Lawes, and the great era of agricultural chemistry began which continued till the end of the last century. During this period agricultural science was a branch of chemistry. As long as the Liebig tradition endured, the analyses of soils and manures were regarded almost with veneration by the practical man, and great hopes were entertained that something approaching a royal road in the development of agriculture had been discovered. This phase lasted nearly fifty years, during which the use of artificial manures became firmly welded into the agricultural practice of the West. Experience of the new science, however, gradually showed that improvements in crop-production could not always be achieved by applying the principles laid down by Liebig. The deficiencies in the soil, suggested by chemical analysis, were not always made up by the addition of the appropriate artificial manure. The feeling slowly developed that the problems of crop-production could not be dealt with adequately by chemistry alone. The physical texture of the soil was found to be as important as its chemical composition. The pioneering work of Hilgard and King in America led to the development of a new branch of the subject—soil physics—the exploration of which is still in progress. Pasteur's work on fermentation and allied subjects discovered a new world and laid the foundation of the modern work on micro-organisms and disease. The soil was soon found to be inhabited by bacteria and other forms of life and a new branch of agricultural science—soil bacteriology—arose. The organisms concerned in the nitrification of organic matter in the soil were discovered by Winogradsky and the conditions necessary for their activity were determined. Hellriegel and Wilfarth worked out the rôle of the organisms which produce the nodules on the roots of leguminous plants and in 1888 furnished

a scientific explanation of the value of these crops in enriching the soil. The Liebig conception of soil fertility was thus gradually enlarged, and it became clear that the problem of increasing the produce of the soil did not lie within the domain of any one science but embraced at least three—chemistry, physics and bacteriology. The great value of this broadening of the basis of agricultural science was to afford an explanation of practices which had been arrived at on the basis of experience and to add a number of important principles to the subject. It was not till the beginning of the present century that investigators began to pay attention to what is after all the chief agent in crop-production, namely, the plant itself. The re-discovery of Mendel's law by Correns, the conception of the unit species which followed the work of Johannsen and the recognition of its importance in improvement by selection have led directly to the modern botanical studies of cultivated crops. These investigations are constantly broadening and now embrace the root-system and its relation to the soil type as well as resistance to disease. It is an arresting fact that the development of modern plant-breeding came about indirectly and did not arise in the most logical manner, namely, as an outgrowth of systematic botany and the intensive study of the Linnean species. Had the principles of systematic botany been rigorously applied to the various units which make up the Linnean species and had anybody collected the numerous forms of almost any wild plant and grown them side by side from single plants, the principles underlying improvement by selection would have been apparent and a sure foundation for modern plant-breeding would have been laid.

The practical results which have followed the application of botanical science to agriculture during the last quarter of a century are very considerable. In wheat, for example, the labours of Saunders in Canada culminated in the production of Marquis—a variety obtained by crossing Red Fife with an early Indian wheat (Hard Red Calcutta). Marquis closely resembles Red Fife in appearance in the field and in the high quality of its grain. It differs from the parent in earliness and in having a shorter straw. Marquis is the most successful hybrid yet produced. Over 20,000,000 acres of this variety are grown in Canada and the neighbouring States of the Union. In Australia, the new wheats raised by Farrer are widely cultivated. In England, Biffen's new hybrid Yoeman has definitely established itself in the wheat-growing areas of the country. In India, the types produced by the Pusa Research Institute already cover more than 2,000,000 acres. The total area of the new varieties of wheat produced during the present century must be little short of twenty-five million acres. At a moderate estimate, the increased wealth produced by the application of modern methods of plant-breeding to this crop must be at least 20,000,000 sterling a year. If this annual dividend is compared with the capital invested, the return is many times greater than that yielded by the most successful industrial enterprise. The methods which have proved successful in wheat are now being applied in India to crops like cotton, rice, jute and sugarcane, and important results have already been obtained. During the next generation, the replacement

of inferior varieties by more efficient and higher yielding types is certain to make rapid progress, and in a few years the total annual addition to the wealth of the world will run into hundreds of millions sterling. Important as is the total annual increment which follows the general adoption of a successful variety, nevertheless the gain per acre is small. Even in the most favourable circumstances it is not likely to exceed twenty rupees an acre. As in the case of Marquis and the Pusa wheats, the advantage is partly due to earliness and partly to the improved quality of the grain. The new varieties are more efficient and make better use of the food materials provided by the soil than the old. Their cultivation secures a more certain crop and also one of increased market value. It by no means follows that the new kinds require more from the soil and that their cultivation will be followed by a loss of permanent fertility. The improvement is closely similar to that obtained by replacing an inefficient machine by one which is better designed to do the same work.

Even when the cultivated area of the world has been provided with better varieties, only the first instalment of the practical results, which flow from the modern studies of crops, will have been secured. The great problem of the agriculture of the near future is the intensive cultivation of improved varieties by which the present production can be vastly increased in quantity as well as improved in quality.

A survey of the development of agricultural science during the last ninety years reveals the important fact that until quite recently the approach has almost always been by means of one science. The researches fall into classes, each class coinciding with the limits of some well-defined subject like chemistry, physics, bacteriology, entomology or botany. Not only can the researches be easily grouped but the organization of agricultural workers closely follows the artificial sub-division of science which has grown up in the colleges and universities as a result of the exigencies of teaching and examinations. Further, the history of the application of each science to agriculture follows much the same course. First of all, there is a period of optimism after the publication of the early results. This is slowly followed by a more chastened outlook as it becomes apparent that the new science is not quite adequate by itself to deal with the many-sided problems of practice. Finally, direction is gradually lost and the effort not infrequently loses itself in detail.

I propose at this stage to examine two of the chief problems which now confront the agricultural investigator in India, and I hope to show that these problems do not fall within the limits of any single branch of science. It naturally follows therefore that the conventional method of attack cannot hope to be completely successful.

Irrigation and agriculture.

The discovery of the right use of irrigation water is one of the chief tasks now before the Agricultural Department in India. As every one knows, everything goes well in this country if the rains are timely, well distributed and ample in volume. Trade flourishes, there is contentment in the villages and in due course the officials

connected with finance have the pleasant duty of announcing either the remission of taxation or suggesting useful schemes on which the surplus revenue can be spent. All this follows because water is one of the limiting factors in the growth of crops. Hence the development of canal irrigation from rivers to supplement the rainfall. At first sight, all that seems needed is that the engineers should dam a river and distribute the impounded water over the country-side according to a time-table. The factor—shortage of water—which limits production can in this way be removed. For the canal to pay its way and to bring in the greatest revenue, the water has to be distributed so that the most expensive crops like cotton and sugarcane can be grown. This involves fairly frequent waterings so that there is no cessation of growth between sowing and harvest. Hence the institution of perennial irrigation and the concentration of the cultivated area commanded so that the highest duty of the water and the maximum revenue can be obtained. When, however, we carefully compare the growth of the same crop under canal irrigation and under normal rainfall, interesting differences can at once be detected. The irrigated crop as a rule does not appear to be quite at home. Ripening is frequently delayed and the quality of the produce is apt to be irregular and inferior. Further, the standard of cultivation under a canal tends to deteriorate. After a few years, the producing power of the soil falls off; patches of alkali land often appear and grow in size and there is a tendency for the villages to become malarious. Compared with the best well-irrigated regions or with localities where the crops are grown on the natural rainfall, the well-being of both plants and animals on the perennial canal leaves a good deal to be desired. Canal irrigation in the hands of the cultivator seems to put a brake on the wheel of life. In some places, as for example on the Nira canal in Bombay, the wheel of life is brought to a standstill altogether by the land becoming a wilderness of alkali on which nothing can grow. Here the canal has produced dead soil. How is it that things have gone wrong and why is there this difference between experience and theory? The answer is to be found in the fact that rainfall and canal irrigation are different things from the point of view of the plant. It is true that rainfall and irrigation have one factor in common, namely, the provision of water. In almost every other respect, however, they are quite different. Rain is a saturated solution of oxygen in water, and usually reaches the soil so slowly and at such long intervals that it does not destroy texture to anything like the same extent as canal water does. Moreover, it supplies the soil with oxygen in a highly effective form. Canal water is much poorer in oxygen, it destroys the tilth and the total period of its application to any particular crop is only a matter of an hour or two. Further, when the surplus irrigation water cannot flow away underground there is a gradual rise of the sub-soil water-level which may reach almost to the surface. Small as these differences at first sight appear, nevertheless they are sufficiently important in the course of a few years to bring about a marked fall in the fertility of the soil.

Why there should be such a tendency towards intense malaria, when dry crops are grown under canal irrigation, is a matter which has not yet been satisfactorily

explained. Is it merely due to the accumulation of surface water providing breeding grounds for mosquitos or is a part of the answer to be found in the lowered resistance of the people? Have the wheat and other food-grains, produced under canal irrigation, the same food-value as those grown under natural rainfall or with the help of wells? Do the nutritive and vitamin values of food grains vary with the conditions of their growth? Science cannot at the moment answer these questions, but there are indications that the food value of the same cereal depends on the conditions under which it is grown. This matter urgently calls for careful investigation. McCarrison [1], working in Madras, was on the eve of throwing light on these questions when his researches were brought to an end by retrenchment. During the course of an exhaustive enquiry into the food value of the rices in common use in India, this investigator found the various kinds differed considerably in nutritive value. No reason for this could be detected in their chemical composition and it appeared that the differences might be due in part to their vitamin content. As rice was not available at the moment, the matter was put to the test of experiment using the same kind of millet from the permanent experimental plots at the Coimbatore Experiment Station. These plots have been in existence about fifteen years and have been manured in various ways. In the feeding experiments on animals, the millet grown on soil manured with cattle manure was more nutritious and contained more vitamins than that grown on soil manured with artificial manure; that grown on exhausted soil being the worst of all in these respects. McCarrison writes "I was in the middle of this work when my researches came to an untimely end owing to financial retrenchments in India, so I was not able to repeat the experiment nor to extend them to other grains." That there does exist a definite relationship between the incidence of malaria and the way crops are grown is suggested by the observations of Bentley in Bengal. In this province, the prevalance of malaria and the inundation of the rice areas are closely connected. In such tracts as Eastern Bengal, which are subject to annual inundation, the rice crops are excellent, there are practically no waste lands, the population is large and malaria exists to so slight an extent as to be almost negligible. In parts of Central and Western Bengal, however, quite a different state of things exists. The greater part of the Districts of Nadia, Murshidabad, Hooghly and Burdwan have been deprived of the natural inundations to which they were once subject by the construction of river-embankments. In the old days, 60 or 70 years ago, these embankments were kept in such bad repair that they did not prevent flooding of the country and their harmful effect was not apparent. When they were made really efficient barriers to the inundation, the protected areas began to suffer in several ways. The fertility of the soil diminished, the area of waste land increased, population declined and with it malaria increased to an appalling extent. Where rice is grown to perfection there is little malaria; where the crop is cut off from the necessary inundation, malaria is rife. In all probability the

[1] *Jour. Roy. Soc. of Arts*, LXXIII, 1925, p. 152.

same rule applies to dry crops like wheat. It may easily prove to be that the intense malaria which often follows in the wake of the canal in North-West India is not altogether due to the mosquito but is a consequence of the lowering of the quality of the food-grains grown under canal irrigation. The subject is one which calls for early investigation, and it is hoped that McCarrison's interesting work on the influence of soil conditions on the nutritive value of the chief food-grains of India will be continued, and that the investigation will be widened to embrace the effect of the quality of wheat on resistance to diseases like malaria.

Of equal importance to the increase in malaria is the deleterious effect of canal irrigation on the fertility of the soil. When the desert is conquered by the canal, all goes well at first and large crops are raised with a comparatively small volume of irrigation water. As time goes on, however, the soil particles fall into a condition of closer and closer packing and as the natural texture of the desert soil is lost, more and more water is needed by the cultivator to raise his crops. Defective soil-aeration soon becomes a limiting factor in growth. The yields begin to fall off with surprising rapidity as is shown by the results with wheat at Mirpurkhas in Sind. The next stage is the appearance of alkali patches which slowly increase in size till the land goes out of cultivation. The rate of transformation of potentially fertile desert soil into useless alkali land is, other things being equal, inversely proportional to the size of the soil particles. Open, porous soils are not affected to any great extent by perennial irrigation. Close, heavy soils, containing a high proportion of fine particles, are, however, particularly prone to develop the alkali condition.

Very little progress in the prevention and cure of alkali soils has been made up to the present in India. All attempts to reclaim these soils on the large scale have proved to be impossible on economic grounds. Further, almost nothing is known of the causes which produce the alkali phase. The conventional view that alkali soils are the natural consequence of a light rainfall, insufficient to wash out of the land the salts which always form in it by the progressive weathering of the rock powder of which all soils largely consist, is persistently reiterated. Hence alkali lands are considered to be a natural feature of arid tracts like the Punjab and Sind where the rainfall is very small. These ideas on the origin and occurrence of alkali land, however, do not correspond with all the facts. Alkali soils are common in the submontane tracts of North Bihar where the rainfall is between 50 and 60 inches. Arid conditions, therefore, are not essential for the production of these salts; heavy rainfall does not always remove them. What does appear to be a necessary condition is defective soil-aeration. Whenever the air supply is cut off by the constant surface irrigation of stiff soils or by other causes, alkali salts sooner or later appear. If these barren areas are examined, they are frequently found to contain the bluish-green markings which are associated with the activities of anaerobic bacteria. These organisms appear to bring about a reductive phase in the soil which involves the formation of substances like sulphuretted hydrogen and the metallic sulphides. When circumstances alter and oxidation again takes place, the salts of alkali land—the

sulphate, chloride and carbonate of sodium—are produced. That the origin of alkali is due to defective soil-aeration which slowly establishes an anaerobic soil flora is supported by a large number of facts and observations. In the alkali zone of North Bihar, wells have to be left open to the air otherwise the water is contaminated by sulphuretted hydrogen, thereby indicating a well marked reductive phase in the deep soil layers. In a sub-soil drainage experiment in the Nira valley, Mann and Tamhane found that the salt water which ran out of these drains soon smelt strongly of sulphuretted hydrogen and a white deposit of sulphur was found at the mouth of each drain, proving how strong was the reducing action in this soil. Here the reductive phase in alkali formation was actually demonstrated. After drainage and aeration were established, the conditions necessary for alkali production were removed and the original texture and fertility of the soil were restored. These and many other examples point to the supreme importance of further investigation of the origin of alkali lands in India and the discovery of the conditions which are necessary for their formation. Once this is known, it will be possible to shape our irrigation policy so that the water can be made use of without lowering the permanent fertility of the country-side. Such an investigation is particularly necessary in India at the present tin e in view of the pending development of canal irrigation in Sind. A barrage is being thrown across the Indus below Sukkur, and a system of intensive perennial irrigation was at one time contemplated for the growth of crops like cotton and wheat. The soil, however, is much closer in texture than that of the Canal Colonies of the Punjab, there are no deep sand layers to assist percolation, and the level of the sub-soil water is comparatively near the surface. There is therefore every reason to fear that the soil conditions of the area commanded by the Sukkur barrage are such that intensive perennial irrigation will produce a vast expanse of dead alkali land.[1] Such a disaster can probably be averted by altering the method of distribution so as to give the land as much rest as possible from irrigation. A new method of irrigation must be evolved (intermediate between the modern perennial system and the old basin method) by which irrigati n and soil-aeration can be combined. This is one of the results which is expected from the new Irrigation Experiment Station in Sind which has just been sanctioned by the Government of Bombay.

The effective addition of water to make up for a deficient rainfall is therefore not a simple matter. It lies far outside the province of the engineer and embraces not only the health and well-being of the people but also the main facts of rural economy as well as the problem of the maintenance of the fertility of the soil. Such questions

[1] In his *Irrigation and Drainage* (London, 1900) King concludes an interesting discussion of this question in the following words, which deserve the fullest consideration on the part of the irrigation authorities in India. "It is a noteworthy fact that the excessive development of alkalies in India as well as in Egypt and California, are the result of irrigation practices modern in their origin and modes and instituted by people lacking in the traditions of the ancient irrigators who had worked these same lands thousands of years before. The alkali lands of to-day, in their intense form, are of modern origin, due to practices which are evidently inadmissible and which in all probability were known to be so by the people whom our modern civilisation has supplanted."

do not fall within the limits of any one science, and it is obvious that their solution can only be accomplished by investigators of great experience, capable of bringing several sciences simultaneously to bear on these problems.

Diseases of plants.

When we turn to the biological aspects of agricultural work, the great complexity of the subject and the interaction of the fields covered by the separate sciences, become most apparent. In following the growth of a crop from the seed, many branches of natural science are involved. The food materials provided by the soil are prepared by bacteria; drawn into the plant and transported by physical means; elaborated into useful products by chemical processes while the resulting growth produces organs which are studied by the botanist. Biological questions are therefore a complex of all sciences. Many of the problems of agriculture, particularly in the tropics, cen re round the growth of the plant. How closely this complexity influences the successful solution of agricultural problems is seen when we consider the diseases of plants.

In recent years perhaps more attention has been paid to the diseases of crops than to any other branch of agriculture. One reason for this would appear to be that the detailed examination of the insects and fungi concerned in plant diseases can easily be carried out by specialists in an ordinary laboratory and do not involve much equipment. In spite of the vast literature on diseases which has accumulated as a result of the researches of the last thirty years, agricultural practice has been remarkably little influenced. This result at first sight appears surprising. It seems so obviously the right thing to ascertain the nature of the pest and to attack its weakest and most vulnerable phase. It is, however, now being recognized that direct attack by assault and battery is nearly always useless and economic entomology and mycology are becoming transformed into plant pathology, thus bringing these subjects into line with the new developments in medical thought.

The moment we begin to study the diseases of plants from a broad standpoint it becomes apparent that a great deal besides the life-history of the fungus or of the insect is involved. The variety of the particular crop is perhaps more important than the parasite and the effect of the environment in both is often very considerable. That the insect or the fungus is only one factor in the problem is seen when large numbers of unit species, belonging to several varieties of a crop like wheat, are grown side by side under similar conditions for a number of years. The resistance of the unit species to the various rust fungi differs widely. Some unit species are practically immune, the rest are attacked to varying degrees. Although there is always plenty of infecting material, the immune types escape.

It has not yet been possible directly to discover on what the immunity of certain species, varieties and unit species depends, but some light is thrown on the subject by another set of observations. It has frequently been noticed that improper

methods of agriculture are almost certain to be followed by attacks of disease even in cases when the variety possesses a fair degree of disease resistance. Moreover, it has been found possible to induce experimentally attacks of disease by altering the conditions of growth. Thus einkorn (*Triticum monococcum* L.), the most rust resistant species of wheat known, became covered with pustules of black rust (*Puccinia graminis* Pers.) when grown during the hot season at Pusa. By altering the time of irrigation at Quetta, peach trees could be covered with green-fly whilst neighbouring trees of the same variety, watered normally, remained free from this pest. Researches in other parts of the world tend to show that this and allied results follow alterations in the chemical composition of the cell-sap brought about by changes in the general metabolism induced by the altered methods of cultivation. The pest will only become acute if certain substances are present in the cell in quantity —a close parallel with the recent work on cancer in Great Britain.

Twenty-five years ago detailed studies of the insect and fungus diseases of the sugarcane were the chief feature of the work of the sugar experiment stations in Java. These are now no longer considered necessary, as experience has shown that the best method of dealing with sugarcane diseases is by the efficient cultivation of suitable varieties. To grow the right kind in the right way is found in practice to be the most important factor in the control and elimination of the pests of the sugarcane. This experience is most significant. The Java sugar industry is perhaps the high-water mark of tropical agriculture and owes its present position to various natural advantages which have been developed to the utmost by the efforts of a succession of highly qualified scientific investigators who have explored, in the greatest detail, the various directions in which the production of sugar can be increased. It is most significant that as the investigation of sugarcane diseases became broadened and included all the factors, direct methods were given up and attention was directed solely to the variety and to its proper cultivation. This is after all only common sense. Disease follows the breakdown of the normal physiological processes in the plant when the protoplasm of the cells loses its power of resistance to the inroads of parasites. Healthy plants, on the other hand, possess a high degree of immunity to insects and fungi. It is obviously more practical to prevent disease altogether by growing the right kind in the right way than to step in at the last moment and attempt to save a moribund crop.

The problems which centre round irrigation and disease are typical of those which now await solution by the man of science. They are not simple questions and they do not lie within the limits of any one branch of science. Each involves a number of factors, and it is obvious that the method of approach by means of the single science cannot hope to do more than accumulate data which may or may not be useful to some master-builder of the future. The approach by way of the single science is really an inheritance of the Liebig phase when agricultural chemistry and agricultural science were synonymous. As the subject broadened and deepend, first one

and then another science became involved with the consequence that workers in these various branches of knowledge became colleagues of the agricultural chemist. The literature dealing with investigation and the teaching in the colleges and universities naturally followed the separate sciences. When about thirty years ago Departments of Agriculture began to make their appearance in various parts of the Empire, the organization was modelled on the teachings of the colleges and the staff usually included a chemist, a mycologist, an entomologist, a bacteriologist and a botanist. As research extended, progress has always been marked by the addition of specialists whose business it was to deal with the application of some particular science to agriculture. Meanwhile the real subjects of research have far outgrown the old tradition founded on Liebig's work and the attack by means of the single science is no longer adequate. Some new method must be devised by which science can be more fully utilized in the advancement of agriculture. If we continue as at present the organization itself will soon become a bar to progress. The immediate question is: Is there any method other than that of the single subject by which science can deal with the problems of the cultivator?

How is the difficulty to be solved and how can science be brought to bear in a more effective fashion? Several suggestions have been made of which it is proposed to discuss two, namely, team work and a widening of the training of the investigator accompanied by a gradual re-organization of existing agricultural departments. The idea of team work in the solution of agricultural problems is a comparatively recent one and is a recognition of the complexity of present day problems. Team work is another name for co-operation by which workers in single sciences can join forces to attack a complex question. It is a useful method for research institutes at which a number of graduates are working as apprentices in methods of research. By this means the post-graduate student not only has the opportunity of using his own knowledge but also comes in contact with the essential nature of large questions. In agricultural research it is an excellent method for certain centres at which experienced investigators can direct and co-ordinate the efforts of advanced students. At the most, however, team work can do little more than make the most of a bad job. It breaks down when the members of the team are isolated and are placed face to face with problems in the strange places of the earth, where the sheltered corners created by the universities and by the endowed experiment station do not exist and where the working conditions can be summed up briefly in the three words—*payment by results*. Further, team work does not help to make investigators who can stand on their own feet. It rather tends to provide a framework for accommodating the unit very much as a regiment does. Another disadvantage is that to be effective team work always requires somebody to lead the team and to maintain direction. It also needs suitable material to lead. Team work in other countries is no new thing. It has long been common in the universities of the Continent where recognized leaders are frequently surrounded by young graduates eager to learn how to make the best use of their knowledge. At many of the Continental

universities, team work was in operation long before the term began to appear in our own literature. It is, however, in the study of biological problems that team work is most likely to fail. As emphasized above, the growth of a living organism like a plant involves many of the natural sciences, and it is difficult to see how team work is to give that insight into vital processes without which all such research remains sterile. A successful biological investigator must be able to visualize the complicated processes taking place in a plant, and to realize that such processes do not take place independently but that each influences the other. That this is being recognized is shown by the modern development at the universities of border line subjects like bio-chemistry, but what is wanted is something more than this; it is an integration in the mind of the investigator of the main facts of the chief sciences which bear on agriculture.

An alternative to team work in agricultural investigation is to so widen and deepen the training and post-graduate experience that the individual can successfully attack problems now attempted by the team. At first sight, such a suggestion is liable to be ridiculed and set aside as utterly impracticable. Nevertheless I am convinced that it is the direction in which progress is most likely to be made. In putting these ideas into practice, however, we are at the outset confronted with a great difficulty. On the one hand, we have to train our future agricultural investigators in several sciences so that they can bring knowledge to bear on the problem in hand from several points of view. On the other hand, as knowledge accumulates there is so much to learn that men have to specialize in one branch of science in order to avoid too long a period of training. There are thus two opposing tendencies to be reconciled. Men who can integrate and who can apply several sciences to an art like agriculture are constantly needed for all kinds of applied work. To advance pure science the specialist is also essential. How far can these two different classes be trained together and at what point must they begin to follow different roads? This is a matter of organization of teaching in the universities. It is one which needs the most careful thought and one which will have to be solved if we are to reap the full harvest from the application of science to industries. Up to the present, the application of science to agriculture, although successful in many instances, nevertheless has not always led to useful results. If only the training could be broadened and the right type of man with the ideal combination of knowledge and aptitude could be set to work on the problems of to-day, it ought to be possible to accomplish more in the next generation than has been achieved during the last hundred years. The problems have been defined and are before us awaiting solution. The scientific knowledge and the ability exist in the great republics of learning. In many cases the means for doing the work have been provided. What is needed is the happy union of all these factors —the trained investigator, the problem and the means.

CO-OPERATIVE MOVEMENT IN INDIA.*

By

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In 1918, when the last Conference of Registrars was held, we were still engaged in the task of adopting the recommendations of the Maclagan Committee on Co-operation, and the last formal resolution of that Conference was one expressing our high appreciation of the work of that Committee and of the excellence of its report. The experience of seven more years' strenuous labour brings us, I venture to think, in still better position to appreciate the great value of the work done by that Committee, and to testify to the good influence its report has exercised on the growth of a sound movement in India.

Since the last Conference, there has been a threefold increase in the number of societies, in capital, and in membership; and the total sum of paid up capital and reserves has risen in a manner and to an extent which is highly satisfactory. But this period has seen comparatively little change in the Act, the rules or the essential bye-laws, and I think you will all agree with me that the growing experience of India bears a most remarkable tribute to the excellence of the scheme for village credit societies which will for ever be associated with the name of Raiffeisen. It is a matter for thought that while so many people of education and intelligence are devoting time and labour and talk to the framing of a constitution for this sub-continent, the hope of the peasantry is bound up with the constitution of a little village association. The Raiffeisen type of societies has proved so successful here, that we may well see in it a message of hope; for if Germany, after fifty years of effort on co-operative lines, was able to break the power of the money-lender and gradually convert her societies from credit to thrift, there should be good reason to expect that similar efforts will in due time produce similar results here. I do not say that fifty years will suffice for India. The task here is so much the greater, and there are special obstacles peculiar to the country and its social system which will only be overcome by prolonged persistent efforts. The greatest enemies of the co-operative movement to-day are those of our friends who wish to force the pace, to rush on to quick results, and to advance without consolidating our gains. The development of the movement must depend on the character of the people and on the ability and capacity of the leaders. In one sense, our most urgent and our

*** Presidential Address to the Ninth Conference of Registrars of Co-operative Societies, Bombay, 12th January 1926.**

greatest task is to discover suitable leaders and to train them in the work. But with the best of leaders, we must not expect to conquer the evil of usury in a single generation. Usury has been a topic of discussion in India from Vedic times ; it has been under regulation since the laws of Manu were promulgated, and its effective control and ultimate elimination are not to be achieved without more efforts than can be crowded into a single span of life.

The great need of the country at this time is sound leadership. It appears to be characteristic of India that while its history is rich with record of religious reformers, and with the stirring achievements of great warriors, it is sadly lacking in economic leadership ; and it is economic leadership which is required if ever we are to secure for the masses of this country a higher standard of living. Economic leadership is somewhat unexciting ; it lacks the passionate element which gives a bite to politics and fire to a really first class religious controversy. It makes little appeal to the unthinking populace, and it is left to those of us who have seen him at work in the countryside to realize what a difference a born leader can make to a group of villages in ten or fifteen years.

I trust that you will bear with me if I attempt to express briefly my own idea of the duties which must be undertaken by the leaders of the co-operative movement. Our Act enjoins us to register societies which have as their object the promotion of the economic interests of their members, and those members must be agriculturists, artisans, or persons of limited means. In brief, we are called upon to deal with promoting the economic interests of the great mass of the people of India—a truly stupendous task. It is what has been called "the staggering problem of Indian poverty" with which we are called upon to deal. I do not admit that poverty is peculiar to this country or that it is here more intense than in many other places, but it is sufficient for our purpose to admit that the standard of living is deplorably low and that it rests with us to attempt our utmost to make progress towards a way out.

It seems to me that the first task is to study the case in detail, to analyse the causes and to discover remedies. We must become experts in the rural economics of our provinces, and we must search far and wide for ideas and suggestions that may lead to solutions. It is the economic condition of the people we are concerned with, and it is their economic condition which we must study. The mere number of the people is itself sufficient to show that we cannot deal with each individually, so that one essential is to associate them into groups and these groups into higher groups until we have built up a manageable organization. It is clear that reliance cannot be placed upon the agency of the State alone or of philanthropists for the accomplishment of a task so vast ; we must teach the people to help themselves and to help each other ; in short, without co-operation there is no hope for the people. Without co-operation, the present low standard of living of the great mass will never be raised to a satisfactory pitch. Many of the people, I admit, can be helped by other means, but not the whole. Whether even with co-operation, the general

level will ever be raised to a decent standard is a problem for the future. Our task is to try.

Our policy must be to educate the people to raise their own standard ; we must educate them in the widest sense : not merely to read and write, but to know, to understand and to put forth the effort. We must devise ways of overcoming the obstacles, and before we can do that we must study to discover exactly what those obstacles are. We must see what there is available, and what there is lacking. In short, before we can teach the people the way out of their poverty, we must find the way out ourselves and that involves intensive study of the rural problem. The first qualification, then, of the leaders must be a real mastery of the economic problems of the village. Co-operation must, to a large extent, be adult education. The Agricultural and the Veterinary Departments in their field of work are engaged in the same task of adult education ; the Department of Public Health must rely upon the same policy, and I am glad to acknowledge the broad-minded efforts now being made in the same direction by our own Department of Education.

Without adult education of the right type, this problem of a low standard of living will remain insoluble. Progress must be by education. And it is upon education that we must rely for success. Those who hanker after quick results are apt to put their trust in amendments of the Act or the rules, in summary procedure or even in compulsion ; but, even at the risk of raising a note of discord, I must give expression to my opinion that there is nothing good or lasting to be gained that way. Our members must do what is right, because they know it *is* right and have been educated to understand that to do what is right is the truest loyalty to themselves, their neighbours and their country.

Our leaders then must realize that their economic end must be gained through the education of the people : education in the positive directions of better cultivation, better animal husbandry, better buying and better selling ; and also in those negative points, abstention from the money-lender, from unproductive borrowing, from waste and extravagance. And here we touch upon what may prove the most difficult problem of all.

The general ideas prevalent in this country are essentially uneconomic. The prevailing customs and sentiments, some fortified by religious feeling, make up a burden beyond their power to bear. We need not seek beyond them for the causes of poverty. Ideas that were suitable enough for a pastoral age when the population was sparse and wild produce of the forest was abundant still hold sway, and to dispel these we must enlist the social reformer on our side. It is hardly sufficiently realized that no European country could avoid bankruptcy if some of these ideas were to spread west-ward. And there is little hope for a better India unless we can secure the acceptance of more economic ideas on matters of everyday life. It must be freely recognized that our ideal of better living can never be attained without something like a comp'ete revolution in the general outlook. There are millions of people in Germany, France, Belgium and other European countries living upon

plots of land as small as those common here; their lives are spent in un-remitting toil; as has been well said, they have to live hard, work hard and save hard. It is a question whether the people here are willing to pay this price for a higher standard of life. If they are not, then the causes of that unwillingness must be searched for and exposed, and the attempt must be made to educate them away.

Our leaders must realize that "better living" is the real goal of all our efforts. "Better farming," and "better business" are merely means to that end. Scientific agriculture is an essential means, but scientific agriculture will never achieve much amongst the masses without the education to make use of it. Practice always lags behind knowledge, and it is for us to hustle practice up to a more neck and neck position.

It is also for us to endeavour to ensure that the type of scientific agriculture evolved by the experts is suitable to the economic condition of the villages. We must try to form some concrete idea of what we mean by the phrase "raising the standard of living," or if you prefer it "better living," and must guide the better farming to that end. We must bring all our studies and our knowledge to the village and interpret the lessons in terms which have a meaning to the people. Unless we can do that, co-operation will be but an empty phrase, and our leaders will see all the fruits of their labours consumed by an increase of population. If, however, we can work out concrete programmes understanded of the people, then there is hope that the future will see a better and happier India.

I do not think I am stating anything new when I stress the importance of creating a new outlook on life for the people. The extraordinary apathy towards improvement and towards ideas of a steady rise in the standard of living must be fought and defeated. We have ample experience of the attractiveness of the life of serenity and leisured ease. In the Punjab, the efforts of Government to afford opportunity to men to achieve a better standard of living in the canal colonies have been to a considerable extent frustrated by the refusal of the people to work when their simple needs can be met from rents. Many others who returned from the great war with savings have ceased to work at all and have become their own pensioners. Industrial leaders again have ample evidence of the tendency of their workers to leave the mill or the mine when they have collected savings sufficient to last for a period of ease. I need not labour the point as it is too well known to all of you; but we must recognize in this preference of leisure for to-day over better living for to-morrow one of the greatest dangers facing all attempts to raise the general standard of the poorer classes.

It becomes increasingly important that we should attempt to arouse a desire for better living through better farming and better business; for a better life through greater effort and for a better India through self-help. The social reformer must be encouraged to do his utmost to attack the ideas that make for contentment with uneconomic conditions. It is a question whether the people of India respond to economic pressure in the way we find in Europe. It is, in my opinion, insufficiently

recognized to what extent our civilization is based upon standards of work, of diet and of female labour forced upon us by centuries of strangling poverty. Europe is far too poor to afford the extravagances which here are accepted without remark.

It may be that our Get-There-Quick enthusiasts may feel some disappointment that my only panacea for the poverty of India is fifty years of hard work, hard study, hard saving, and hard living; but I feel confident that those who have devoted sufficient time to the problem will agree that no other policy holds out such sure hope of ultimate success. Already we can point to definite progress. We are gradually building up a sound system of rural credit which we hope will displace the vicious system which has persisted since the earliest times, and we hope that this Conference will facilitate the further development of this work. We are trying to create credit for the benefit of the borrower, instead of the lender; and we are trying to teach the borrower the right use of the credit which is being placed within his reach. In several provinces, we are now attempting to initiate a land mortgage policy on sound lines, which we trust will go far to abolish the worst evils of the right to encumber property which everywhere has proved a temptation too strong for the small owner to resist. We are trying to link up our system of rural banking with the better known commercial banking; success in this direction will bring benefit to both. At the moment we are far behind in business methods, but if our education campaign makes good progress we should inspire greater trust in the minds of our more advanced neighbours. For the moment we play the lesser part in the movement of crops, but that will soon be reversed; and the two systems working in collaboration should be able to save much of the waste attendant upon the existing necessity of using actual cash. Some of our friends in the world of commercial banking do not understand how we can base credit upon character and mutual liability instead of tangible and saleable security, and it is for us to prove that this can be done with success. Here again, education is an absolute necessity, as it is upon the right type of education in credit that our hopes must be based.

Then, there is the widely different series of problems connected with development of small industries. Just as with the cultivators so with these, the joint stock banks cannot offer direct help, and we must leave them to the money-lender and the exploiter of labour, or come to their assistance. The financing of these small industries in accordance with co-operative principles presents special difficulties, and we seem unable to travel far without the expert aid of the Departments of Industries which must educate the workers to improve their outturn. It seems to me extremely important that we should develop this side of our activities, for the simple reason that the larger part of the problem of Indian poverty consists in finding profitable employment for the extensive leisure of the people. The ideal of working for half the year and that other ideal of office hours from 10 till 4 will never make India a great country. There must be methods evolved of finding profitable and productive employment for the leisure hours of all adult members of the family. The tiny

plots of land which the majority of cultivators attempt to subsist on will not provide whole time occupation for every one, and it is from the income of the spare time that we must expect to earn those extra amenities which make up a higher standard of living. The occupational caste system must go. The cultivators and their families here as in Europe must devote every spare moment to subsidiary industries or to work of a nature calculated to raise the general standard. The raising of the standard of living means greater consumption of commodities or services, and the production of those commodities or services must find employment for the spare hours. It means a prolonged campaign of education, but it is possible of achievement.

In the above, I am afraid, I have been rather hard on the politicians. I have said nothing about them. I am afraid that there is little likelihood of any one of them putting "fifty years' hard work" as the first plank of his programme, and we must not be too hard upon them if they select something more attractive. They can assist by adhering strictly to sound economics, and by avoiding popular panaceas which only lead to heavy economic loss. They can assist by insisting upon the teachings of experience and research, and by avoiding that indulgence in sentiment which is the bane of progress. They can assist by adopting all measures calculated to preserve internal and external peace, for without this we shall never develop that feeling of certainty of reaping the reward of extra effort which alone will prove sufficient stimulus. They can assist by accepting and acting upon the doctrine that this country will never advance far along the path to better living without vast expenditure on scientific research, propaganda and education.

India is far too poor a country to be able to afford economy in such matters; a wise expenditure will pay better than narrow-minded cheese-sparing, and our political friends can render valuable service in explaining this to the less educated of their followers who demand economic suicide in the hope of a little evanescent popularity. Further, our politicians can serve our movement by leaving it outside their polemics. We want no politics in Co-operation.

Gentlemen, I trust that one result of our deliberations this week will be to encourage us to work yet harder and with renewed faith for the uplift of the agriculturists, artisans and persons of limited means in this country. Of discouragement we have more than enough, and we all admit a goodly share of failures, but I think we all have found grounds for hope in the future. I think the reports on progress in different provinces will provide material for an optimistic view. Our best societies show us what can be achieved, and if you consider that every province has something good to show, we ought to be able to multiply the best by careful education. Whatever else, we must always bear in mind that the whole object of the movement is to benefit the individual members of our primary societies; everything else is subordinate to that end, and in our discussions I trust that we shall not allow ourselves to be diverted from the interests of our members to the admiration of some second-

ary or central body. I trust further that we shall not wander into the controversy of official or non-official control; the man at the bottom is the person that matters; there is work for all, non-official and official; our one wish must be that that work be done.

THE SUPPLY OF SEED OF IMPROVED VARIETIES OF CROPS FROM PUSA.

BY

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THE work of the Botanical Section at Pusa during the past twenty years has resulted in the production of improved races of several of the more important field crops. This work was carried out under the direction of Mr. and Mrs. Howard, the late Imperial Economic Botanists, and the seeds of these improved varieties were by them widely distributed throughout the agricultural areas to which they were suited. A large part of the Botanical Area at Pusa is still devoted to the production of seed of these races, and a quantity is available for distribution every year. The following is an account of the seed which are available with a few notes on the characters of the different types.

1. WHEAT.

There are three types of wheat available for distribution—Pusa 4, 12 and 52.

Pusa 4 is an early wheat of good standing power and rust resistance ; it is beardless and has an exceptionally large grain with felted glumes. In a normal year in Bihar it should be sown at the end of October at the rate of 40 seers* per acre; this relatively high seed rate is necessary as this wheat does not tiller well and possesses a large heavy grain. Pusa 4 is well suited to the climatic and soil conditions of Bihar, and has also done well in the Bundelkhand districts of the United Provinces and in the N.-W.F. Province. In Australia it took the First Prize at the Royal Agricultural Show at Sydney in 1916, 1918 and 1920, and is one of the wheats regularly distributed by the Queensland Agricultural Department. It also gained a special prize at the Food Products Exhibition at Calcutta in January 1920. Pusa 4 will grow and yield well under minimum conditions of soil moisture ; being an early maturing variety of low tillering capacity it generally yields less heavily than other Pusa wheats, but under favourable conditions very heavy yields have been recorded from this wheat. In the Botanical Area at Pusa yields of grain of 36 maunds† per acre were obtained in 1925, an exceptionally favourable season of optimum moisture conditions, and in 1920-21 a yield of 40¾ maunds per acre was obtained under estate conditions at

* 1 seer = 2 lb. † 1 md. = 80 lb.

Bhagalpur. In the United Provinces in 1921 this wheat yielded 26·4 maunds per acre over 15·5 acres. Pusa 4 may be recommended to cultivators wherever an early ripening variety of low water requirement and good grain quality is required. The grain has a thin skin and contains a high percentage of flour ; as a result of this thin skin it is liable to lose its power of germination unless properly stored during the rainy season.

Pusa 12 is later in ripening than Pusa 4, and is a beardless wheat with smooth red chaff and good straw. The ears are somewhat longer than those of Pusa 4, and the grain is lighter in weight than that of Pusa 4. This wheat tillers well and a seed rate of 30 seers per acre should be sufficient. It is well suited to the climatic and soil conditions of the United Provinces and the Punjab, and has been successful in Bihar. It is a heavy yielding wheat, and in the United Provinces in 1921 yielded 26¼ maunds per acre over an area of 50 acres. In Bihar Pusa 12 appears to be inferior in rust resistance to Pusa 4, but is better in this respect than other local wheats.

Pusa 52 is a new wheat produced by hybridization, in which the high yield and bearded nature of one parent (Punjab 9) is combined with the high quality of rust resistance of the other parent (Pusa 6). The grain is slightly smaller than that of Pusa 4 and the chaff is smooth and white. The straw is strong and in Bihar this wheat stands well and is resistant to rust ; it is a heavy yielding wheat and in the Botanical Area has given 27 maunds per acre over an area of 4 acres. This wheat tillers well and should be sown at the rate of 30 seers per acre. It has not yet been distributed on the scale of Pusa 4 and Pusa 12, but on account of its bearded character probably has a wide popularity before it ; it is considered that it will prove especially suitable for North Bihar and also in other provinces where Pusa 12 has given good results.

2. Linseed.

Many different types of this crop have been isolated at Pusa, and two of these appear to be especially suitable for growth in North India. The Indian linseeds fall roughly into two classes, the deep-rooted large-seeded types which are adapted to the soils of Central India and the shallow-rooted small-seeded types which are suited to the Gangetic alluvium. The two types which are considered to be the best for the North Indian soils belong to the latter class.

Type 12.[1] A late flowering, much branched type, very erect, crowded and compact in habit, with dark green foliage. The flowers are white and the seeds small and brown.

Type 121[1]. This type is medium in maturity and resembles Type 12 in habit but the flowers are violet. The seeds are small and brown.

[1] *Mem. Dept. Agri. India, Bot. Ser.*, Vol. XII, pp. 159 & 179.

In a series of comparative tests in 1923 both these types gave yields of 40-50 per cent. above that of the local variety, and in 1925 in the Botanical Area yields of 14½ maunds per acre from Type 12 and 16 maunds per acre from Type 121 were obtained.

3. Gram.

Of the 25 types of gram which have been isolated at Pusa, two, Types 17 and 25, are available for distribution.

Type 17[1]. A late ripening plant of somewhat spreading habit; leaves with a yellowish tinge and slight redness on the apices of the teeth of the leaflets, midrib reddish. Flowers pink with violet wings, seeds reddish or yellowish brown.

Type 25.[1] This plant ripens earlier than Type 17 and is more erect in habit. Foliage is dark green and the flowers pink with a deep red shade; seeds reddish brown when fully ripe.

The best yields from these grams are obtained on light, high-lying, well-drained soils which are not in very good condition as regards fertility. In Bihar sowing should be rather late, about the first week in November, by which time the light lands will have lost a good deal of their moisture. In 1925 in the Botanical Area these grams gave yields of 26 maunds of grain per acre.

4. Tobacco.

The seed of Pusa tobacco type 28 is available for distribution. This type is an isolation from the local crop and should be sown, transplanted and cultivated according to the local practice in Bihar. The plant is relatively hardy and the leaves are thin in texture but stand up well clear of the ground; as many as 14 to 18 leaves may be obtained from a single plant and a yield of from 10 to 15 maunds of dry leaf per acre can be obtained according to the quality of the soil and the care bestowed on its preparation. This tobacco is specially suitable for cigarette manufacture, and large quantities of its seed have been distributed among the ryots of Bihar by the Indian Leaf Tobacco Development Co. The following is a description of the plant :—

Plants[2] very late, tall; height 159 cm.; leaves numerous; plants bushy; lower internodes very short, causing many leaves to lie on or near the ground, upper internodes very long; inflorescence much raised on numerous long, slender branches; flowers sparse. *Leaves* sessile, inserted at an angle of about 45°, and bend downwards from the centre of the leaf, amplexicaul, decurrent for 4 to 7·5 cm., the decurrent strip of lamina very narrow; shape elliptical; breadth of the leaf decreasing with its position up the stem, lamina much reduced in the basal third of the leaf; apex acuminate; secondary veins arise at an angle of 45°, veins much lighter in colour than the lamina, and therefore very conspicuous; margin very undulate;

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[1] *Mem. Dept. Agri. India, Bot. Series,* Vol. VII, pp. 232 & 233.

[2] *Mem. Dept. Agri. India, Bot. Series,* Vol. III, p. 134.

surface puckered, lamina raised between the secondary veins, giving the appearance of folds or ridges ; leaf not expanded but folded on the midrib ; colour glossy bright green; texture medium to thick ; average length 50 cm. ; ratio length 1 breadth 2·5. *Inflorescence leaves* very similar to the lower leaves except as regards their shape which is lanceolate. *Inflorescence* much raised on long slender branches which are somewhat spreading in habit. *Flowers* sparse, a very deep pink colour which does not fade ; length 45 mm. *Calyx* tubular, inflated, a little less than half the length of the corolla ; teeth short and acute. *Corolla* with an orifice 8 mm. in diameter, and a fairly broad tube, the transition between the tube and the dilated portion gradual ; limb divided to about half its depth with folds at the junctions of the lobes ; lobes rounded at the base ; apical points short ; limb never fully expanded. *Capsule* a little longer than the persistent calyx, cylindrical ; apex blunt.

The anthers burst in the bud when just above or just level with the stigma. In the open flower they maintain their relative positions and are below the orifice of the corolla.

5. Hemp (*Hibiscus cannabinus* L.)

This fibre plant is widely cultivated throughout India for local consumption, and several types have been isolated at Pusa. Type 3 is a tall unbranched variety which appears to be well suited to the climate of Bihar and North India ; it is a heavy yielding type and the seed is available for distribution in small quantities. The following is a description of the plant :—

Plants[1] fairly early, very robust, setting much seed. *Stem* tall, stout, prickly, red except the upper 6 or 7 inches which remain green. *Stipules* green. *Leaves* palmately divided into 3-7 (usually 5) lobes, a few are simple and subcordate, the upper leaves lanceolate, green ; margins red ; petiole red. *Peduncle* green. *Epicalyx* green. *Sepals* green with a few red spots. *Corolla* yellow with a crimson eye. *Seedlings* somewhat small, stem red ; petiole red ; cotyledonary leaves green.

The quantity of the above seeds which is produced yearly in the Botanical Section is limited, and indents from intending purchasers should be addressed to the Imperial Economic Botanist, Pusa, Bihar, and should be sent in before April, as the bulk of the seed is disposed of immediately after harvest.

[1] *Mem. Dept. Agri. India, Bot. Series*, Vol. IV, p. 21.

CO-OPERATIVE DAIRYING IN INDIA : A PLEA.*

BY

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THE development of co-operation amongst the agricultural classes in India has been largely done by Government officials at Government expense, whereas in many countries where agricultural co-operation has made great progress, the movement has been initiated, guided and financed by public-spirited private citizens actuated by patriotic motives, and the countries where this form of patriotism has proved of greatest benefit to agriculturists are generally those where the land is cultivated by small holders either owning the soil or having a right of tenancy thereto. The application of co-operative principles to rural development in such countries has taken many forms, agricultural credit being probably the foremost ; but next in importance to co-operative finance it may be safely said comes co-operative effort in the development of the dairy industry in those small holding countries which have applied co-operation to the solution of their rural problems.

India is a country of small holdings cultivated by peasant proprietors or those having recognized tenant rights, and although agricultural co-operation has made great progress in many directions in this country, yet up to the present no serious attempt has been made to develop the dairy industry along co-operative lines. This is probably due to many causes; amongst them the fact that the cow-owner classes in many parts of the country are ignorant and generally wholly in the hands of the money-lenders, and naturally those responsible for the conduct of Government Co-operative Departments set themselves to provide facilities to enable the Gowala to obtain freedom from the thraldom of the usurer before they attempted to assist him to develop the technical side of his business. Meantime the dairy industry and with it the cattle-breeding industry (for the two are unavoidably bound together) goes from bad to worse. Milk becomes dearer and dearer in the urban areas. In many of the villages the poor cannot obtain it at all, and the quality of the white liquid offered for sale in the cities as milk is an insult to the name of the cow.

The best remedy for this deplorable state of affairs lies, in my opinion, in the organization of the milk producers into co-operative societies and the prosecution of a vigorous campaign for this purpose by the Co-operative Departments of all Governments.

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*Paper read at the Agricultural Section of the Indian Science Congress, Bombay, January, 1926,

The extraordinary success which has attended the efforts of the Co-operative Department of Bengal in the organization of the village milk producers around Calcutta, and in the collection, handling and sale of the milk from these village cow-owners shows what can be done where the question is tackled by resolute men who have faith in the efficacy of their principles and methods, and there is no reason whatever why the example of the Calcutta Co-operative Milk Societies Union should not be repeated all over the country.

Private enterprise with capital at its command has tackled the development of the cotton industry in India. The collection, grading, sale and manufacture of many of our staple products like wheat, tea, jute, lac, sugar, and tobacco have been taken up by our industrial magnates with remarkable success, but up to the present the Indian capitalist has fought shy of the dairy industry, mainly, I believe, because public opinion in the country is not strong enough to protect him from unscrupulous competition in the form of adulteration. It is an impossibility at the present moment to buy milk in quantity in any part of India which is free from adulteration, and the only remedy for this is the establishment in all producing areas of co-operative societies composed of the milk producers. Milk in India, whether sold to be comsumed as fresh milk or to a separator owner to be converted into butter or *ghee*, is invariably adulterated by the producer in the main hope that by adding to its quantity he will obtain a greater money return for it, whereas this adulteration really increases the cost of handling, injures the quality of the article and consequently reduces its value. So long as the small illiterate milk producer sells his product direct to a private person or firm, there seems little hope that he will be persuaded to stop his time honoured custom of adding water, and often dirty water at that, but if this producer becomes along with all his immediate neighbourers who are milk producers a member of a democratic society for the sale of their produce, a public opinion is at once created amongst that community which has a force, and the action of every member of the society in the shape of adulteration of produce or unclean methods, affects the income of every other member of the society. It naturally follows that in such a society you have a unit within which discipline can be enforced, and rules applied providing for the greatest good of the greatest number.

Not only would the formation of such societies go far to solve this adulteration problem, but they would accumulate capital within the industry, and provide a means in their corporate capacity for the dissemination of technical knowledge on all matters connected with cattle breeding, rearing and management, and the production and handling of milk and milk products.

It is a significant fact that the highest quality dairy produce in the world comes from countries where the dairy industry is almost entirely worked on co-operative lines. The manufactured dairy products from countries like Denmark, New Zealand and Holland have commanded the highest prices in the world's markets since these countries applied co-operative methods to their dairy industry, and this is certainly due to a large extent to the democratic nature of co-operative production, and to the

fact that this very system of democratic interdependence compels the dirty and irresponsible producer to mend his ways, because until he does so the rest of the producers associated with him are called upon to bear part of the cost of his delinquencies.

One of the main reasons why the cultivator in India will not give that degree of attention to the breeding and rearing of cattle which many consider desirable, is that he does not find cattle rearing profitable,and there seems little hope of improving the condition of affairs in this direction unless and until it can be assured that the breeder can obtain a reasonable price for the milk of his cow or buffalo. In the direction of improving the economic aspect of cattle-breeding and of securing for the cattle-owner a fair price for his milk either in the shape of fresh milk or a manufactured dairy product, lies a great field for co-operative enterprise in India. Not only can co-operative dairy societies eliminate the middleman in the sale and manufacture of dairy produce, not only can they enforce a standard of purity which private individual effort cannot obtain, but they unite the milk producer for a common object, and form a nucleus for the teaching of improved methods of growing and conservation of fodder, of cattle husbandry, of milk production, handling and sale, and of business methods and habits of thrift. In those dairy countries like Denmark where agricultural co-operation has revolutionized methods, eliminated the usurer and made the small holders comparatively wealthy, the creamery or milk purchasing organization has been the primary society. The first thing to be done is to prove that by the better handling and sale of the milk of members, their economic position can be improved, and then to organize those members who have tested the benefits of co-operation into societies for the improvement of their herds and crops, the recording of the milk of their cows, the purchase of their agricultural requirements, the treatment of their cattle in sickness, and into combination of any legitimate kind for the advancement of their moral and material welfare. In this direction and on these lines there is, I believe, a great future for the dairy industry in India, and this brief note is submitted to the Indian Science Congress to call the attention of those interested in rural economics to this aspect of co-operative agricultural activity.

DISCUSSION.

Col. Matson stated that he had always realized the importance of co-operative agencies in milk production, and expressed his surprise that, in the Punjab, co-operative activity had not been manifested in this direction.

Dr. Mann, Director of Agriculture, Bombay Presidency, said that he had been wrestling with the problem of the Bombay city milk supply for some considerable time. He doubted how far co-operation could help at present in the solution of this problem. The supply was mainly derived from individual producers in the city and the cows were kept in byres in town conditions. There did not exist at present any material for co-operative organization. The only alternative at present was to develop production on correct lines within a reasonable distance from Bombay. The all-important matter was to get the milk, and he considered that this could only be done by production on a large scale. In Bombay city, there is a necessity for milk production on capital-

istic lines first. Co-operation, if it comes, will follow late. At present, the supply is the chief difficulty ; co-operative production is a secondary matter. He welcomed, however, the co-operative experiment in milk supply at Calcutta.

Rao Sahib Bhimbhai pointed out several difficulties attending the organization of co-operative milk production. Taking India as a whole not much advance in this direction had been made. Finance seemed to be the greatest obstacle, and he supported the last speaker in his contention that milk production in India at present was a matter primarily for capitalistic enterprise.

Mr. Main asked the President if any information was available with regard to the conditions around Calcutta where co-operative milk production had proved successful.

The President stated that he had no first-hand information on this point.

Col. Matson stated that he had investigated this problem in Calcutta where the conditions were quite different from Bombay. The co-operative organization consisted of a large number of small holders and the management was good. The supply of milk received was pure.

Dr. Mann said that he also had made detailed inquiries in this connection. The primary difference was that near Calcutta the small cultivators produced fodder for cattle and did not go in for the cultivation of crops antagonistic to cattle-keeping. Also all the milking is done by officers of the co-operative organization who maintain milkers in each village. This greatly reduced the danger of adulteration.

Mr. Ezekiel of the Palghar Milk Supply Company, Bombay, stated that the difficulty was to find a suitable market for the milk sent to Bombay in competition with the adulterated milk produced in the city. The milk was firstly distributed from door to door, but this method was expensive and complaints were received from customers. The conversion of milk into cream and butter resulted in a reduction of profits. His company suffered a loss of Rs. 10,000 on a capital of Rs. 200,000 in one year. Now the company is just making both ends meet. The overhead charges are very high.

The President enquired what training the people responsible for the management of this commercial concern had received.

Dr. Mann, in reply, stated that at present the Palghar dairy was being managed by a man trained at the Poona Agricultural College. He thought Mr. Ezekiel had painted a rather black picture of the company's work. The year before last, a considerable profit was shown, but last year an attack of rinderpest had reduced profits considerably. He said that there were three great difficulties which such dairy companies had to contend with. Firstly, the impossibility of competition against the unscrupulous Bombay produce ; secondly, the difficulty of retail trade; and thirdly, the high overhead charges which production was not able to sustain. He would welcome a stiffening up of milk re_ulations, and he insisted that such companies should be big enough to carry their overhead charges.

The President pointed out that the discussion had been practically confined to city milk supply, and indicated the possibility of co-operative production in purely rural areas. He mentioned the difficulty of dealing with " flushes " of milk at the commencement of the rainy season and the problem of itinerant herds of dairy cattle.

Mr. B. S. Patel described the organization of milk supply in Ahmedabad city.

Mr. Jenkins, referring to the difficulty mentioned of competing with adulterated milk supplies, expressed his opinion that a large demand for pure milk, sold under guarantee, must exist in a city like Bombay, and that, if suitable advertisement of pure milk sold under a guarantee of purity was underta en, this difficulty would not be a real one.

Dr. Mann replied that such a system of retailing pure milk under a guarantee would considerably increase the expense of sale, and that only by large sales the business of milk supply could be profitably carried on.

Mr. Ezekiel added that a prejudice existed against pasteurized milk and that there was no encouragement for the sale of milk under a guarantee of purity.

MOSAIC DISEASE OF SUGARCANE IN INDIA IN 1925.

BY

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The chief symptom by which mosaic disease of sugarcane is recognized is the peculiar mottling of the leaves. Minute areas of the leaf are of a paler green tint than the rest of the leaf, or of a yellowish green or even a whitish green. The pale areas are somewhat elongated in the direction of the long axis of the leaf. They vary in length usually from a quarter of an inch to an inch or two, and in breadth from one-eighth to a quarter of an inch. They may be few or numerous. In the former case the disease is somewhat difficult to diagnose but in the latter case a kind of rough pattern of pale and dark green areas is formed, and it is this mottled appearance that has suggested the name "mosaic" disease. The pale green areas may, however, be so extensive that in the extreme case the leaf is pale green with pieces of dark green lying like islands more or less isolated from one another. There is thus a wide variation of pattern which, however, is fairly constant for each variety of cane. The tint and the extent of the markings seem to depend on the age of the cane and the stage of the disease. It is not easy for one who has not previously seen the disease to recognize it from a description, but it is hoped to print later several examples in colour. The very young leaves do not show the mosaic markings. The recently unfolded leaves show them most clearly and that usually on the lower half of each leaf. In general, it is true that the older the leaf the less distinct is the mottling. On the Coimbatore canes no mottling is visible from about the 5th or 6th leaf downwards. In Red Mauritius, however, the mottling may be clearly visible as low as the 16th leaf. In 1925 in Pusa mosaic markings were first noticed on Co. 213 about three months after planting, but as the rate of growth depends on the degree of atmospheric and soil humidity which varies considerably from season to season the first symptoms may be expected to appear somewhat earlier at least in some years.

This disease was first described in Java in 1892 and has been the subject of considerable investigation ever since, more especially perhaps after its appearance in various parts of America and the adjacent islands. At the present time it occurs in most sugarcane-growing countries, *e.g.*, Java, the Philippines, New Guinea, Formosa, Queensland, Fiji, Hawaii, Egypt, Natal, Argentine, Brazil, Surinam, Demerara, New Orleans and Louisiana, Trinidad, Barbados, Porto Rico, San Domingo, Jamaica, Cuba and India.

Though often looked for in India by various workers, it was not noted till 1921 when Dastur[1] found it at Pusa on D.-99 and Sathi 131. Mr. Noël Deerr, who has a unique opportunity of knowing large areas of cane in Bihar and the United Provinces and has had opportunity of seeing mosaic in Hawaii, Porto Rico, Cuba and Java, suspected its presence on Hemja and Co. 213 during 1923 and 1924, but specimens sufficiently typical for a certain diagnosis were not actually seen by the Imperial Mycologist. At the end of 1924, Mr. Noël Deerr sent specimens of leaves of Co. 213 in 4 per cent. formalin to Java, and 25 per cent. of the leaves were stated to be infected with mosaic, whilst the others had chlorosis which might be due to nitrogen starvation or bad conditions for the root system. In May 1925, a typical case was found at Pusa in Co. 213 by Mr. L. S. Subramaniam, Assistant to the Imperial Mycologist, and during the next two months the disease appeared on several other varieties. Immediately the search was extended into Bihar and to other parts of India, and in this the Government Sugarcane Expert gave considerable help in suggesting places where he suspected the canes had markings somewhat like those in Pusa and in the published illustrations. Agricultural stations were chosen because they usually have most of the canes that grow in the surrounding district, and the intention was first of all to discover the presence of mosaic rather than the extent of the area infected, for this can be mapped out more easily by mycologists in the provinces than by the small staff at Pusa.

The following canes were found to have mosaic :—

Bihar. Pusa (New Area)—Co. 205, Co. 210, Co. 213, Co. 232, Co. 248, Co. 250, Co. 275, Co. 281, Co. 282, Co. 286, Co. 287, Co. 288.

Pusa (Silk House Area)—Co. 205, Co. 213, Co. 281, Co. 286, Co. 287, Co. 288.

Pusa (Farm)—Co. 213.

Sabour Agricultural Station—Co. 213, Red Mauritius.

Various Estates—Co. 210, Co. 213, Co. 232, Hemja.

United Provinces. Aligarh Agricultural Station—Co. 213, Co. 232.

Bulandshahr Agricultural Station—Co. 213, Co. 232, Co. 281.

Kalai Demonstration Farm—Co. 213, S. 48, B. 6308, Mauritius 16.

Punjab. Gurdaspur Agricultural Station—Co. 210, Co. 231, Co. 232, Co. 242, Co. 247, Co. 257, Co. 258, Co. 261, Co. 265, Co. 270, B. 6308, S. 48, A. 2.

Madras. Palur Agricultural Station—M. 55, B. 147, B.208 D. 1135, Fiji B, Java-Hebbal, Chittoor-Poovan.

Samalkota Agricultural Station—J. 247, B. 208, B. 254, D. 625, D. 1135, A 95, Purple Mauritius, Red Mauritius.

Coimbatore Central Farm.—Java-Hebbal, Vellai, Poovan, Co. 1.

Bombay. Manjri Agricultural Station.—Java 33 A, Java 36, Red Mauritius.

[1] Dastur, J. F. The Mosaic Disease of Sugarcane in India. *Agri. Jour. of India,* Vol. XVIII pp. 505-509.

In all these canes the presence of mosaic was determined on fresh material. I examined those in Bihar, Mr. L. S. Subramaniam those in the United Provinces, Punjab and Madras except in the Central Farm, Coimbatore. There Mr. S. Sundararaman, Government Mycologist, Madras, identified the disease, and Dr. F. J. F. Shaw, Imperial Economic Botanist, did so in Manjri. Besides the canes mentioned, leaves of J. 213 from Tatkon and of Gillman cane from Sahmaw pickled in about 4 per cent. formalin solution were received recently from Mr. D. Rhind, Government Mycologist, Burma, and showed mosaic markings, but a diagnosis on fresh material has to be made before these varieties can really be declared with certainty to have mosaic.

Though the Government Sugarcane Expert reports that the Coimbatore Sugarcane Breeding Station is free from mosaic,[1] there is some evidence to show that the disease has existed there. In May 1923, a consignment of Coimbatore seedlings, *viz.*, Co. 210, Co. 213, Co. 214, Co. 221, Co. 225 and Co. 232, was sent from the Sugarcane Breeding Station to the Department of Agriculture, Reduit, Mauritius, and in October 1924, the Director of Agriculture, Mauritius, reported to the Government Sugarcane Expert, Coimbatore, that after satisfactory growth in the nursery these canes at about three months old developed unmistakable evidence of mosaic and they had to be destroyed. Again in February 1924, a consignment of seedlings, *viz.*, Co. 210, Co. 213, Co. 214, and Co. 232, was sent from the Sugarcane Breeding Station to Cuba, and in February 1925, the Director, Eastacion Experimental Y Escuela Agricola San Manuel Orient Cuba, reported to the Secretary, Sugar Bureau, that some of them were affected by mosaic disease so that they had to be destroyed. Because of the way in which they were packed, it was impossible for the canes to have become infected in transit and presumably precautions were taken to protect the canes from local infection in the second instance. Unfortunately, the facts were not reported to the Mycological Section, so that no strict search was made in the station. In June 1925, the canes were examined by Mr. L. S. Subramaniam, both in the Central Farm and in the Cane Breeding Station in Coimbatore, but no cases of mosaic were seen then. In the former place, however, the disease subsequently became apparent on four varieties of cane. It looks as if the disease had once been present in the station but has now been eliminated.

Specimens of cane leaves with suspected mosaic markings were sent pickled in 4 per cent. formalin by Mr. Venkatraman and by Mr. Mitra to the Director, Proefstation Voor de Java-Suikerindustrie, and he determined the presence of mosaic on all the leaves submitted. The former also sent similar specimens to the Pathologist, Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, and he replied that the leaves showed unmistakably the typical appearance of mosaic disease. Thus in addition to the recognition of the disease by the leaf symptoms on fresh material in the field, confirmation by other workers outside India has been obtained.

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[1] *Sc. Repts. of the Agri. Res. Inst. Pusa*, 1924-25, p. 146.

I have refrained from stating the amount of mosaic on each of the varieties examined in the various places because the observation in most cases was limited to a single visit. Many Coimbatore canes are on the list and in the majority of cases these were being grown only in very small trial plots and were but slightly infected, sometimes indeed only one clump being infected. In Pusa where the plots have been under continuous observation, the only Coimbatore cane that is fully infected is Co. 232. Co. 250 has 20 per cent., Co. 287, 15 per cent., Co. 210 and Co. 213 have 5 per cent. of clumps infected, while all the others have very few mosaic canes. One plot of Co. 213, however, planted in October 1924, had nearly 10 per cent. of the clumps infected. Co. 232 was also fully infected in the other stations where it was examined. Co. 213 and Co. 210 are canes that are being grown on a large scale in Bihar, and the loss due to mosaic in them cannot, I think be estimated by eye observation. Co. 214, the other cane of this class grown on a field scale here, has not been observed to have mosaic. No mention has been made of the Coimbatore canes of which there is a considerable number that have not shown mosaic markings, as we do not yet know whether the absence of symptoms is due to lack of the chance of infection or to resistance. Of the thick canes examined, Red Mauritius, Purple Mauritius, Mauritius 16, B. 6308 and A. 2 were always fully infected. Hemja, the local cane in Bihar, is heavily infected throughout Northern Bihar. It is very stunted and will produce a light yield of cane. There can be little doubt but that a large part of the loss is due to effects of mosaic. In a paper[1] on "The Sugar Industry of the Indo-Gangetic Plain" an Occasional Correspondent states that mosaic is spread all over Northern India, and that the unrecognized overhead loss due to mosaic is probably very great. Now that the disease is known to be present, it would be well that the loss be determined by suitable experiments in all the agricultural stations in the areas where the disease occurs, and that considerable attention be paid to all the new varieties particularly those of the Coimbatore series for possible tolerance and resistance.

Other facts point to the belief that the monsoon of 1925 was particularly favourable for the development of disease in crops in Pusa. For example, *Helminthosporium turcinum* (leaf-spot) was epidemic on maize, whereas formerly it occurred only in small quantity. *Physoderma Zea-Maydis* was common on maize, whereas it has not hitherto been found in Pusa, the only previous record being that of its occurrence in the Dooars in 1910. *Uromyces decoratus* (rust) on sann-hemp has been found in Pusa since 1921 in very small quantity, but this year it was in epidemic form. The uredo stage of *Puccinia Kuehnii* (Krüg) Butl., similar to that on *Saccharum spontaneum*, was found on sugarcane for the first time. Towards the end of the monsoon and afterwards *Cystopus candidus* and *Peronospora parasitica* (mildew) were epidemic on mustard. The rainfall of 46·5 inches was not abnormal but it was irregularly distributed.

[1] *The International Sugar Journal*, XXVII, p. 534, 1925.

A consideration of all the evidence leads me to think that mosaic disease is not a new introduction into India, but that it has existed among the thin canes of Northern India for a long time. During 1925, it appeared in epidemic form throughout a large tract of Northern India on Hemja, the commonly grown indigenous cane. The canes introduced and selected by Agricultural Departments during the last 20 years and those produced in Coimbatore during the last few years have been so carefully observed by so many skilled workers in different places that it is impossible to believe that the presence of mosaic disease on them would have remained undetected for any length of time. It seems probable that the disease originated in Hemja and passed to these new canes. The disease is probably endemic in India, and Hemja is probably tolerant.

Note. Early in 1926 Mr. D. Rhind, Government Mycologist, Burma, reported mosaic on J. 213, J 33 A, B. 376, Purple Mauritius, Striped Mauritius, Java-Hebbal and Gillman Red from two localities in Burma, Mr. Dastur reported it on Java 213, Co. 203, Khari and Mauritius at Tharsa, Adhartal and Waraseoni in the Central Provinces, and Mr. S. Mitra, Economic Botanist, Assam, reported it on J. 247, J. 1507, J. 1547, P. O. J. 2714, B. 147, B. 3412, B. 6308, D. 74, D. 625, Co. 16, Co. 17, Co. 210, Co. 273, Boga Pura, and Striped Mauritius at Jorhat in Assam.

SUGARCANE-BREEDING TECHNIQUE—ISOLATION OF LIVE ARROWS FROM UNDESIRED POLLEN THROUGH ARTIFICIAL ROOTING OF CANES.

BY

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AND

R. THOMAS,

Botany Assistant.

I. BAGGING OF ARROWS ADVERSELY AFFECTS SEED SETTING.

ONE of the chief difficulties experienced in the breeding of sugarcane is the inability to protect with paper or cloth bags treated arrows against unintended pollen reaching them. It has been the experience with most cane-breeders that the use of cloth bags, sufficiently thick to prevent passage of pollen, weakens the enclosed arrows and results in comparatively poorer germination.

The writers of this paper have, to some extent, met this difficulty—with respect to cross-pollination operations—by dusting the mother arrows copiously and efficiently as soon as the stigmas are ready ; and trusting to secure the intended crosses through the prepotency of the dusted pollen over any wind-borne pollen that may reach the stigmas later on.[1] Experience during the last half a dozen years has shown that this method can be relied on with a fair degree of certainty. More than one seedling of value has resulted from the work which testifies to the utility of the method on the practical side.

It has all along been felt, however, that for any accurate work it would be necessary to rule out all possibilities of doubt about the parentage of the seedlings raised. During the last four years experiments have constantly been in progress in various directions with a view to improve the technique for securing greater certainty in the breeding operations.

II. ISOLATION OF TREATED ARROWS TO PREVENT PROMISCUOUS POLLINATION.

In a field of arrowing canes the atmosphere is at times—chiefly in the mornings and forenoons—fully laden with pollen of the different varieties in flower at the

[1] Venkatraman, T. S. Sugarcane-breeding in India—Hybridization to testing. *Agri. Jour. India*, Vol. XX, Pt. 3, p. 178.

time. Unless suitably protected—bagging is not satisfactory in the cane—the chances of promiscuous pollination are large. If, therefore, the arrow could be removed to a place which is free from such pollen laden atmosphere, the subsequent operations could be carried on with a greater degree of certainty about parentage.

One of the earliest attempts in this direction consisted in the uprooting of whole clumps of the desired parents and isolating them in a suitable manner away from the rest of the field. It was soon realized, however, that the operations involved were expensive, laborious, and—what is perhaps the worst drawback—altogether too unwieldy to allow their adoption on anything like a large scale. Incidentally, it may be mentioned that, for rapid and successful results, sugarcane breeding has to be carried out on an extensive scale on account of the absence of any well established laws in the matter of inheritance in this plant and the rarity with which the desired type of seedling is obtained. It is not uncommon to have to raise hundreds of thousands of seedlings before a desired type becomes available. A thorough simplification and cheapening of the methods employed with the consequent possibility of their being used on a large scale is, therefore, very important in cane breeding.

III. The rooting habits of the sugarcane.

The series of root studies [1]—in soil as well as in culture solutions—which has been in progress at Coimbatore for some time, had shown that in a clump the component canes and even the young shoots are often fairly self-dependent in the matter of roots. The daily examination of the progress in root development, which the growing of canes in artificial culture media rendered possible, showed that one of the earliest activities of a shoot, developing from a clump, was the production of roots from its own root zones. The roots were found to develop almost as soon as the internodes were formed. (Pl. VI, fig. 1.)

A comparative study of roots developing from individual canes in a full grown clump showed that the later canes and shoots developed thicker and stronger roots than the early formed canes, the original set roots being the thinnest of the lot. (Pl. VI, fig. 2.) This observation goes to confirm the independent nature of the individual canes of a clump in the matter of obtaining nourishment from the soil.

On the above data the writers felt encouraged to initiate experiments at separating from the mother clumps those canes which it was known would flower during the season and which were needed in the breeding work. It was argued that the operation would prove successful and the evolution of the arrow continue in the normal manner, if steps were taken to protect the roots of the individual canes from injury

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[1] Venkatraman, T. S., and Thomas, R. Sugarcane root systems. *Agri. Jour. India*, Vol. XVII, Pt. 4, July 1922.

Venkatraman, T. S., and Thomas, R. Simple contrivances for studying root development in agricultural crops. *Agri. Jour. India*, Vol. XIX, Pt. 5, Sept. 1924.

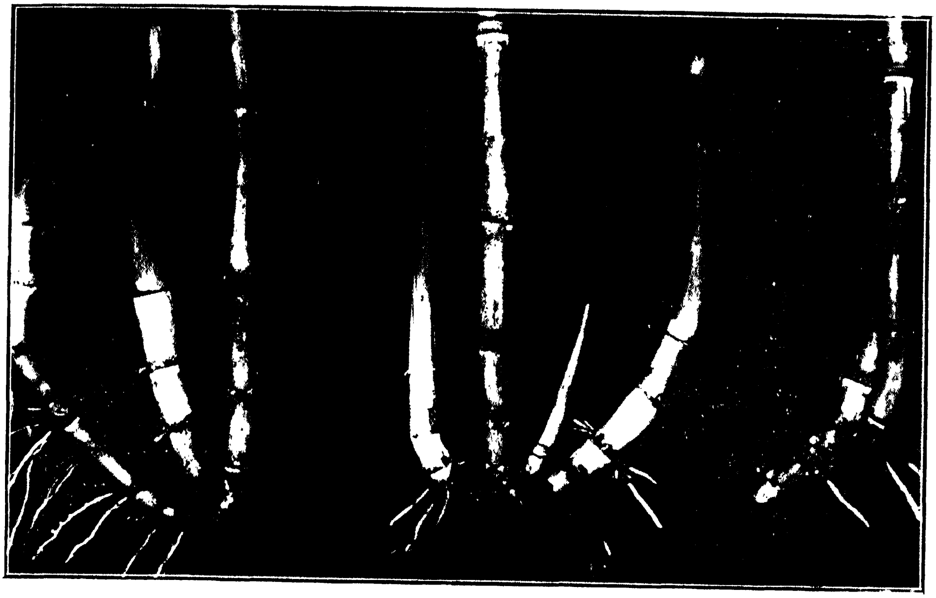


FIG. 1. Some of the canes and shoots dissected out from a mature clump to show the rooting on each member.

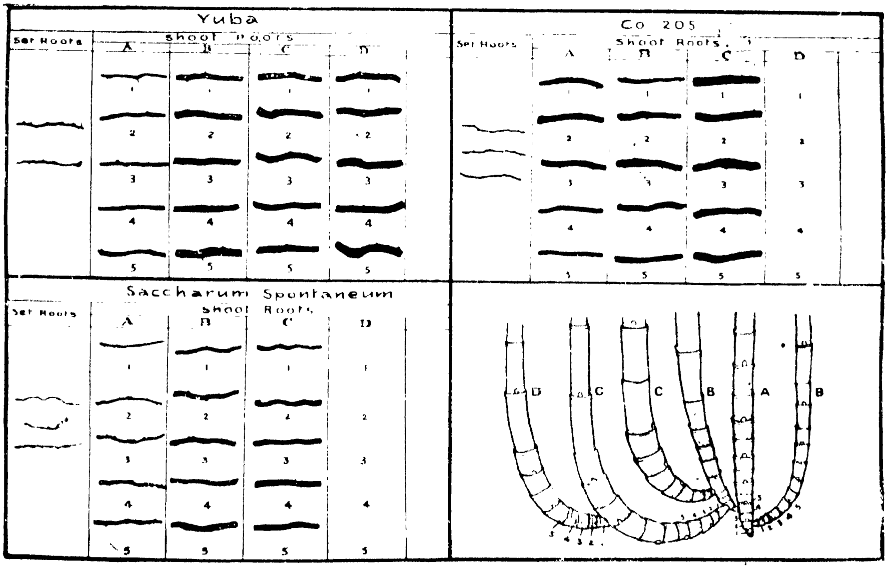


FIG. 2. Shows the relative thickness of roots developed from the different canes of a clump. The diagram at right hand bottom corner denotes the scheme adopted in mounting the roots. The roots were pasted on card board and photographed. A, B, C and D represent canes of different orders in the matter of origin; and the numerals denote the root zone from which the average root has been taken for the picture.

during and after the separation of the canes from the original clumps. It was further obvious that any success at special inducement of rooting on the cane would be a distinct advantage.

The free development of roots from the root zone region, whenever that region happens to come into contact with moist soil, is a common enough experience with sugarcane growers. Further, a profuse rooting from the "eyes" soon after a heavy rain will be well within the recollection of most cane planters. Such rooting is particularly noticeable in varieties with adhering leaf-sheaths; in these cases the favourable moisture conditions at the bases of leaf-sheaths after a rain are apparently responsible for the rooting.

It was frequently noticed that lodged canes—portions of which had come into contact with moist soil and developed roots from the root zones—could be almost completely severed from the parent clumps without seriously interfering with the further growth of the severed canes. Such a behaviour is very characteristic of the cane and directly led to the development of the method described in this paper.

IV. Preliminary indications of arrowing in the cane.

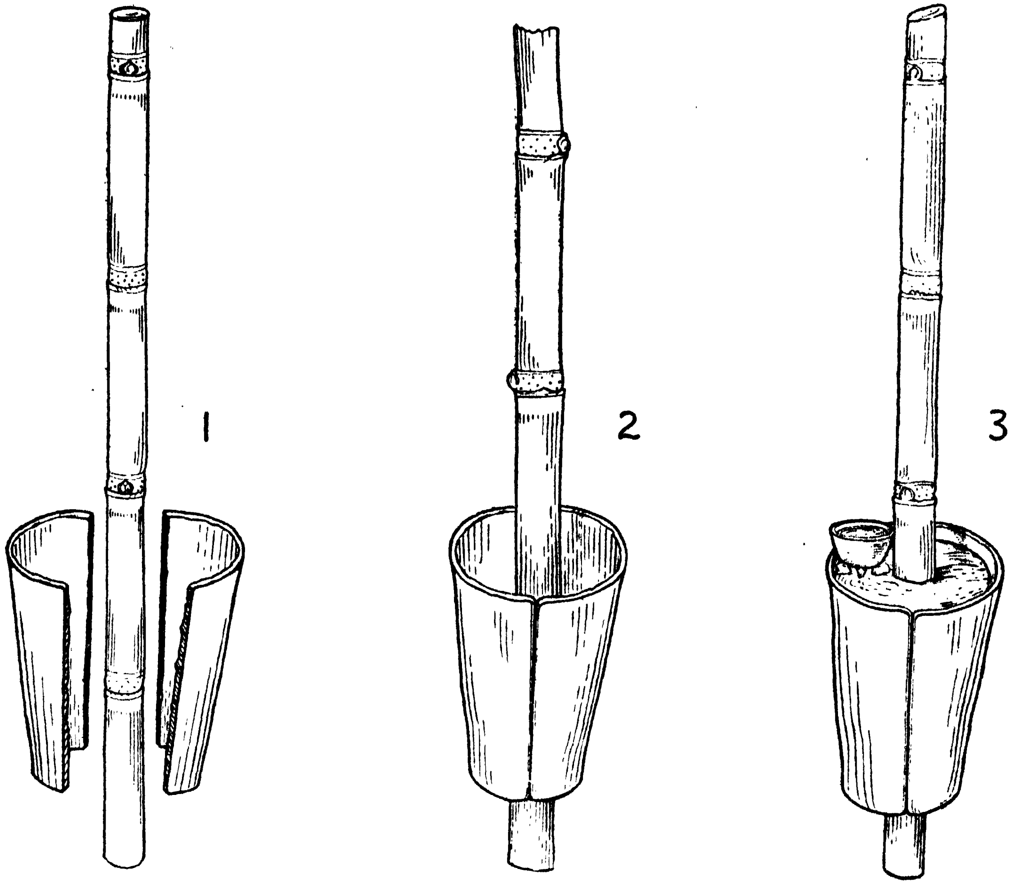
The selection and marking of the canes which would arrow during the season presented little difficulty. The indications which are familiar to every cane breeder are noticed almost a month in advance of the actual arrowing. This kind of forewarning is an asset of considerable importance, as the period gives ample time for the manipulation and treatment of the required cane with the object of forcing the cane to develop a sufficiency of its own roots.

V. Artificial rooting of canes in short blade to render them independent of the mother clump.

Canes which show the necessary indications for arrowing are marked and the basal portions of the canes up to a height of about a foot are specially treated for root development. The treatment consists in applying round the cane a packing of moist soil with a large proportion of sand, keeping the soil in position by means of two tile pots (Text figs. 1 and 2) and maintaining the soil in a moist condition.

For maintaining the moisture in the soil surrounding the canes, it had to be watered at frequent intervals during the early days of the experiment. Later on, however, an earthenware cup with a hole at the bottom plugged with cotton thread and placed on the tile pot was used with advantage. It was found that the passing of water from the cup to the soil could be adjusted to a nicety with experience. The

arrangement is simple, cheap, and similar to the device often resorted to by gardeners (Text Fig. 3.).



This treatment of the basal portion of the desired cane is undertaken about fifteen days in advance of the probable arrowing of the particular cane; this period has been found to be quite sufficient for inducing the requisite rooting in the treated

PLATE VII.

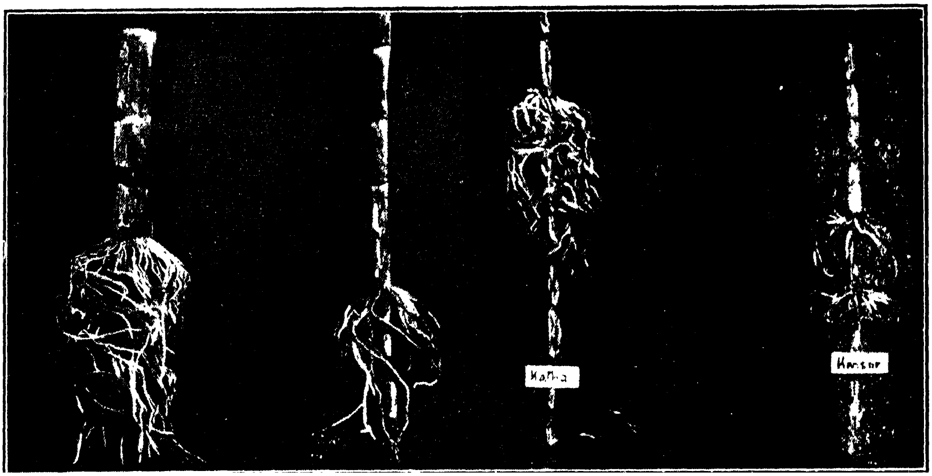


FIG. 1. Illustrates the rooting from the nodes after fifteen days' treatment, from the basal joints (two on the left) and from the middle joints (two on the right). Sugarcane varieties show interesting differences in the readiness with which they respond to the treatment.

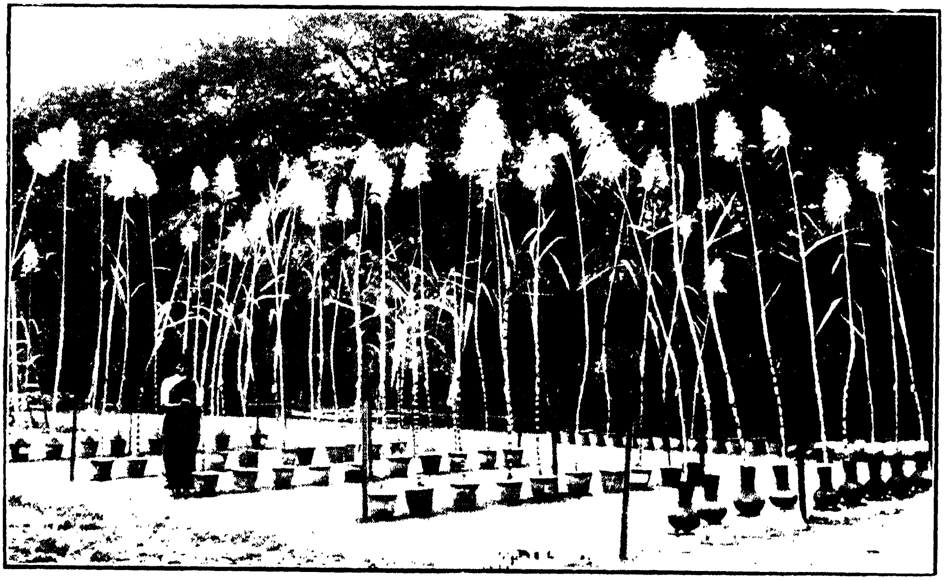


FIG. 2. Shows a group of treated canes after isolation in the seedling house. The row to the extreme right shows the canes in the country watering pots. The ordinary garden pots are seen in the other rows in the picture.

portion of the cane. (Pl. VII, fig. 1.) The treatment for rooting need not necessarily be applied at the base of the canes only. By suitable bamboo erections the treatment could be given half way up the cane or even higher if need be and the canes subsequently cut below the place of treatment.

VI. Removal of treated canes from the field.

When the treated cane has to be isolated—*i.e.*, a little before the time for the emergence of the arrow—it is cut immediately below the tile pot. The cane with the tile pot is now gently dropped into a large size garden pot and filled round with soil. The two halves of the tile pot are now removed. The arrowing cane can now be shifted about and treated very much like a potted plant. The artificially induced roots on the cane are practically undisturbed during the operations with the result that the growth and development of the arrow continues as if the cane was attached to the original clump. For facilitating the severance of the treated cane from the clump, the cane is cut in a horizontal direction half way through, just below the bottom of the tile pot when the cane is taken up for treatment.

VII. Behaviour of arrows from treated canes.

Over hundred individual canes belonging to as many as twenty different varieties were treated in the manner above described during the last arrowing season and removed to the seedling house and away from the field of canes. In the latter place the arrows were noticed to grow and develop in quite a normal manner. (Pl. VII, fig. 2.) Neither the pollen nor the ovaries appear to have suffered appreciably from the treatment as seen from the results in the table below.

Anther and seed germination results from control *and* treated *canes.*

Variety	Percentage of open anthers from arrows of		Number of germinations from equal quantities of seed	
	Control cane	Treated cane	Control cane	Treated cane
Kansar	95	96	101	156
Red Ribbon	92	90	8	11
Purple Mauritius	99	97	35	96

Anther and seed g rmination results from control *and* treated *canes*—contd.

Variety	Percentage of open anthers from arrows of		Number of germinations from equal quantities of seed	
	Control cane	Treated cane	Control cane	Treated cane
Striped Mauritius . . .	82	71	85	10
Green Sport	85	83	36	30
Red Sport	86	87	206	31
Manjav	88	85	60	20
B. 3412	73	86	141	235
P. O. J. 2022	98	98	36	26
P. O. J. 920	60	63	180	54
Co. 213	48	39	99	56
Co. 214	100	100	306	377
Co. 229	95	98	430	583
Co. 244	100	100	100	76

In the above results it may safely be assumed that the differences in results, sometimes in favour of the control and at other times in favour of the treated cane, are well within the limits of individual variation familiar to the cane breeder.

VIII. Discussion of results.

The method* above described appears to possess certain distinct advantages. Firstly, the cane is kept in almost its natural condition during the development and growth of the arrow. Secondly, the method is simple and capable of being adopted with success by any intelligent gardener. Thirdly, the pieces of apparatus

* In a very valuable paper entitled " A Method of Handling Cane Tassels for Breeding Work " (*The Hawaiian Planters' Record*, Vol. XXIX, No.1, January 1925, pp. 84-94), Dr. J. A. Verret and his collaborators describe a method of keeping the cane arrows, normally developing, by immersing the bottom joints in dilute SO_2 solution. The method was tried on about fifty arrows, and healthy and viable pollen was obtained all through the emergence of the arrow. It was found, however, that the seed setting had been adversely affected. It needs to be mentioned here, however, that it was found difficult to keep the solution free from sulphuric acid for any length of time at Coimbatore work. The authors mention that freedom of the solution from sulphuric acid is an essential condition for the success of the treatment.

used are cheap-- a tile pot costs half an anna and the earthen cup a sixth of an anna —and could be made in almost any village. Fourthly, the treatment appears to have no appreciable adverse effect either on pollen formation or seed setting of the arrows.

The only disadvantage would appear to be, the need to treat the canes about a fortnight earlier than the time when the arrows are actually needed ; but, as the programme for the season has often to be drawn up in advance, the disadvantage is not very great.

IX. SUMMARY.

(1) One chief difficulty in sugarcane breeding is the inability to protect sugarcane arrows, after treatment, with cloth or paper bags without adversely affecting germination.

(2) In the absence of bags there is always room for doubt about the parentage of any batch of seedlings.

(3) To remedy this defect an attempt was made to remove the live arrow away from the field, and isolate it in a place where there is no risk of unintended pollen reaching the arrows.

(4) A method of treatment is described by which a cane in short blade could be severed from the clamp and isolated as desired. The method consists in inducing special rooting on the above-ground portion of the cane and removing the cane with the artificially developed roots. The pieces of apparatus employed are of country earthenware—simple, cheap and available almost anywhere.

(5) The treatment has no appreciable harmful effect either on pollen formation or seed setting in the arrows.

POSSIBILITIES OF DEVELOPING THE POULTRY INDUSTRY IN INDIA.*

BY

MRS. A. K. FAWKES,

Secretary, United Provinces Poultry Association.

THOSE of us who have studied the development of other great countries must have been struck with the remarkable part which poultry farming plays in contributing to the food supply of the world. Among the Western nations the United States of America leads the way. The approximate value of her poultry products in 1922 amounted to the vast sum of over 400 million pounds sterling, exceeding the value of her wheat production. Among Eastern nations China most easily leads the way. I have with me the figures of her export trade to Great Britain only, which in 1924 amounted to 2½ millions of eggs in shell and the export of dried and liquid eggs to some £2,542,000 sterling, but she is exporting also to many other countries.

At the recent World's Poultry Congress held in Spain, India was one of the few great countries of the world which did not accept officially the invitation to be represented. This is not desirable for the future, for it is from India that mankind has received the greatest contribution to the poultry industry in the past. Is it not generally accepted that the jungle fowl "gallus bankiva" of our land is the ancestor of the species? It is an accepted fact that it is to the Indian game (asil) and to the Chittagong and Brahmapootra fowls that the magnificent breeds which science has enabled us to develop in the Western world, owe their origin.

The point for discussion at this important Congress is, "Can India develop this industry with advantage to her people?" I think from the results of the small beginnings made I shall be able to prove to you that we have a big future ahead, and that India could compete with China in this trade and supply the ever-increasing demand for eggs to the outside world if her resources were organized. Now what are those resources? I have no definite data to go upon, but as we travel through the length and breadth of this vast Empire no animal is so commonly found as the domestic hen. The numbers must run into many millions. To visitors from the West the extremely small egg and the small type of fowl is a very striking feature. The reason for this in most cases is probably due to promiscuous in-breeding combined with continuous under-feeding. But the indigenous fowl of India possesses valuable qualities of stamina and resistance to disease and adaptability to climatic

* Paper read at the Agricultural Section of the Indian Science Congress, Bombay, January 1926.

extremes, and there are valuable races of fowls in India, now unhappily dying out, that are well worth preserving and should in my opinion be used as a foundation on which to build future high producing stock. The Chittagong breed is one example. It has been my privilege during the past six years to inaugurate, for the first time in India, poultry farming on modern scientific lines, and a brief history of what has been accomplished may be of some interest to you. To Sir Harcourt Butler, Ex-Governor of the United Provinces and now Governor of Burma, is due the conception of a cottage industry, by means of improved methods of poultry farming, being fostered in the United Provinces. He invited me to organize a scheme. I adopted three methods of attack on the problem of how to improve the poultry of the province.

Firstly, by means of propaganda work. I toured the chief districts of the province giving illustrated lectures on poultry farming, showing the wonderful result that could accrue from better methods and better stock. I encouraged correspondence on the subject and wrote articles to the press.

Secondly, at all the principal agricultural fairs of the province poultry exhibitions are held, to which we invite those who keep fowls both for pleasure and as a means of livelihood to bring their best birds for competition. We award prizes in cash and in pure bred stock to the selected winners.

Thirdly, at Lucknow we have built up a modern poultry farm where for the past six years we have successfully bred highly fecund stock and where we are training young men in the scientific principles of poultry farming. This farm is run on a commercial basis and sells birds of highest fecundity and eggs for hatching all over the country. I train my students to hatch and rear chickens most successfully by means of incubators; poultry diseases are studied and kept at bay by rigorous sanitation; different Indian feeding stuffs are correctly fed to the stock and their values ascertained. I am glad to say that some fifty students have passed through my hands and gone out to manage poultry farms in various parts of India, or to start farms of their own.

Many of my students are high caste Brahmins, and I have endeavoured to raise the industry to its proper level, and to show them that modern poultry farming combines all the student can desire in the way of a field for his enterprise. Besides the value of the poultry farm at Lucknow as an educational centre, we have successfully proved beyond question the following points. Firstly, that highly fecund poultry imported from overseas can be successfully kept in India, can be successfully bred from and that the acclimatized stock continues to produce in a remarkable manner. Secondly, that the ordinary domestic fowl of India can be graded up and improved even in one generation by mating the ordinary desi or mongrel hen with males of pure bred fecund stock, sons of high producing dams.

We have verified this in our breeding experiments on the Lucknow farm. We have followed the methods advised by Pearl and Lippencott. To give one instance only, an ordinary *desi* hen was mated to a brown Leghorn cock, the son of

a heavy laying hen, and one of the daughters of this union was isolated and her eggs recorded. During the cold season of 1922-23 in the months of November, December and January she laid 61 eggs in 66 days. These months being the period of low production in an unimproved hen, we thereby proved to our satisfaction that this hen inherited both the primary and secondary physiological factors, *viz.*, that of early production combined with high production from her sire. When one considers that from 60 to 80 eggs is the normal annual output of a good village hen, this record is remarkable.

The same results on a larger scale have been realized in the Etah District of the United Provinces. The population of this district is largely made up of the very poorest and depressed classes, and, under the supervision of Mr. Slater, a well-known missionary philanthropist, large stocks of pure bred, high producing cocks have been given out in the villages, combined with settings of eggs. The results after a few years of work have astonished us; for now, throughout this district, are thousands of pure bred and high producing fowls, laying numerous and large-sized eggs, and the sale of this produce has augmented to a very considerable degree the means of livelihood of this very poor community. I leave it to the imagination of my audience to picture how great a means we have here of ameliorating the lot of some of the poorest of our people, and what a potential increase might be added to the food supply of India which, if not required by her own people, is in demand abroad. A few years of organized effort on scientific lines is all that is required; poultry reproducing themselves so rapidly, it is not the costly and lengthy proceeding that it is with cattle and higher animal breeding that is now being attempted.

The fruit of the hen, as scientists know, is, next to milk, one of the most pure and valuable foods in existence. It is rich in vitamins and lecithin, and though as yet unappreciated by the vast majority of our people for various reasons, it would form for them a valuable food, especially for those who subsist on rice as their principal diet and where milk is scarce.

At the Lucknow farm we have educated the public to realize that infertile eggs, the produce of young unmated hens, should be used for eating purposes and the produce of carefully mated mature birds reserved for reproduction purposes only. It is not generally appreciated that the infertile egg can be so easily obtained and is so much better for commercial purposes owing to its keeping properties.

Our records of egg production compare very favourably with other countries. Every cold season we hold an egg-laying test, open to the world, and each year we receive entries of birds from some of the leading British and Australian farms, and poultry breeders from all over India join in. Some wonderful records have been put up by the birds, the highest record of eggs laid being 86 eggs in 92 days of the cold weather months, a period denoting the future production of hens so tested. The science of feeding is also taught to our students, as of all the factors that control production, feeding is one of the principal, for quite 60 per cent. of the cost of production is traceable to feeds.

Up to the present time little or no attention has been paid to the digestible nutrients of poultry feeds, though, from a review of literature on hand, it would appear that fowls can digest little or no fibre, and are most efficient in digesting the nutrients in the order of nitrogen-free extract, protein and fat.

The Indian domestic fowl has mostly to find its own living, but with higher producing stock suitable feeding will be essential. India is rich in valuable and inexpensive poultry feeds, and I consider this country pre-eminently suitable for the rearing of vast flocks of fowls. Its many waste areas could support immense numbers of poultry to the mutual advantage of both lands and birds. Each fowl contributes not less than 80 pounds annually of valuable manure to the land over which it ranges. Fruit and poultry grow well together.

Owing to favourable climatic conditions the housing of poultry need not be on any expensive or elaborate scale. We have found at Lucknow that open air conditions are the best; the only protection necessary is shade from the tropical sun, shelter from heavy rain and high winds and protection against wild animals. Indian methods of shutting up the fowls in mud houses with little or no ventilation are very objectionable and lead to many diseases of the respiratory organs among domestic fowls.

One of our problems is to protect fowls from the invasion of the parasite *Argas persicus*, which abounds all over the tropical parts of India. This parasite is most resistant to the action of insecticides. Certain specimens can remain alive for five years without food, remaining dormant for long periods. Their pathogenic action on fowls is very disastrous. Besides causing death by depletion, when a large number of adult *Argas* or their larvæ attach themselves to fowls, these can, by inoculation of their saliva, produce various forms of paralysis and intoxication, and by the invasion of different kinds of spirochætes, which they transmit at all periods of their evolution, cause death by avian spirochætosis to vast numbers of fowls.

To prevent the attack of *Argas* on the Lucknow farm we have adopted special perches isolated from the sides of the houses, and the supports of the perches pass through cups of oil. This prevents night attacks. To prevent their breeding in the cracks and joints of the poultry houses, we flame the houses with a blow lamp. Infected fowls can be successfully treated with intravenous injections of salvarsan, neo-salvarsan or soamin. It is interesting to point out in this connection that Ehrlich discovered his famous "606" remedy for human syphilis whilst studying the action of arsenical preparations on the pathogenic spirochætes of fowls. As you are aware, fowls are being studied very largely in the Western world in relation to the problems of cancer research, the control of sex, the effect of vitamins in food, the mysteries of gynandro morphism and other fascinating and complex studies.

I hope, from the facts regarding poultry development in the U. P., you will be convinced that there is a future for poultry farming in India. My reasons for

putting this matter before you are prompted by the demands of Indians themselves for training and knowledge on this subject. There are numbers of educated young Indians seeking an outlet for their energies and a means of livelihood. Why not train them in poultry farming? My post brings me innumerable letters daily, asking for advice and information, and, had I the equipment and staff, I could train many. There is also a great opening for the small cultivator to add to his income by increasing and improving the poultry of his village and his own holding.

In China it is the peasant with a few hens that contributes to the vast revenue earned by that country in poultry products. These eggs are collected in centres, travelling by rivers and roads to factories, where the eggs are either converted by means of vacuum driers into egg powder, or cooled and canned in liquid form for the markets of the world. All this is done by the peasant cultivator and is a cottage industry. I have manufactured successfully in India this desiccated egg powder, in cooperation with the Imperial Bacteriologist.

I commend, therefore, this subject to the careful consideration of this Congress, and plead for the brains of the country to consider the economic value of poultry farming in its relation to India, asking that if this country decides to develop this industry, you scientists will take up the scientific research and investigational work to solve the peculiar problems that are bound to arise in connection with the progress of aviculture in this land of ours.

DISCUSSION.

The Hon'ble Mr. A. M. K. Dehlavi, Minister for Agriculture, Bombay Presidency, thanked Mrs. Fawkes for the valuable information contained in her paper. He stated that he spoke not as the Minister for Agriculture, Bombay, but as a member of the Indian Poultry Club. Poultry keeping had been one of his hobbies for some considerable time and he was still intensely interested in it. It was a subject which required much study and he found Mrs. Fawkes' paper true to the letter. Organized poultry keeping on scientific lines would be infinitely more profitable than the haphazard methods in general use in India at present. The Hon'ble Minister expressed the hope that there would be a great future for poultry keeping as a village industry, and he outlined several of the main difficulties to be overcome before this can come about. He mentioned the necessity of educating the cultivators in poultry diseases and in proper feeding methods and material. Nothing could be more discouraging to the poultry breeder than the loss of a large number of his stock by disease. He stated the intention of the Bombay Government to establish a poultry-breeding centre in the presidency for encouragement of the industry, and concluded by expressing the hope that India would soon take the prominent place she was entitled to in the poultry industry.

Dr. Mann said that he had encouraged Mrs. Fawkes to submit this paper as he realized the possibilities of the expansion of the poultry industry in Western India. He stated that practically no prejudice against poultry-keeping was to be found in the Bombay Presidency, but there were other difficulties to be overcome. In the expansion of the industry, two lines should be developed. Both start from herds of pedigree fowls Firstly, poultry keepers should be supplied with the best stock and with first-class advice and attention. Secondly, efforts should be made to breed large numbers of improved varieties of cockerels for distribution in the villages. The danger of loss from disease was not serious if suitable precautions were

taken. Danger of loss by wild animals was also important. He hoped to make this meeting the starting point of new interest in the poultry industry in the Bombay Presidency. A central poultry-breeding centre—as mentioned by the Hon'ble Minister for Agriculture—was to be started at Poona, and it was hoped to have subsidiary farms in other centres in the districts. He concluded by stating his willingness to co-operate with any central authority in the matter of developing the industry, and expressed his intention of making a beginning by founding a poultry farm in Sind.

Mr. Jenkins mentioned that he had received inquiries from leading egg-importers in Scotland with regard to the possibility of obtaining large supplies of liquid eggs from India. He stated that there would be no difficulty in obtaining a market for such products. He laid stress on the possibilities of improving local village poultry by the distribution of pedigree cockerels, and instanced the valuable work done in Nasik and Khandesh in this direction by the late Mr. C. A. Beyts, I.C.S., whose recent lamented death had been an immeasurable loss to all interested in poultry-breeding in the presidency. He drew the attention of the Congress to the possibility of poultry improvement at the large railway centres where, at present, were to be found many people specially interested in this branch of agriculture.

The President asked Mrs. Fawkes if she could outline a method of poultry improvement in villages and indicate how a beginning should be made. He also mentioned the difficulties existing at present in the transport of pedigree poultry stock by rail.

Mrs. Fawkes, in reply, stated that her poultry farm at Lucknow was a commercial institution and could not undertake free distribution to villages. At Etah in the United Provinces, however, under charitable auspices, this work was going on successfully and good results were being obtained. To improve the poultry of any village, all the *desi* cocks should be removed, they could be bought in at bazar rates and sold for eating. Pedigree leghorn cocks should be substituted at the rate of 1 cock to every 20 village hens. If this is done early in the cold weather, a large half-bred stock would be available by March. She said that improvement could be carried on both by cross-breeding and by selection within existing breeds. Both methods were important. Mrs. Fawkes concluded by expressing the hope that the development of an egg export trade should not be delayed until poultry improvement advanced, but should be undertaken immediately.

SELECTED ARTICLES

THE ORGANIZATION OF SCIENTIFIC RESEARCH THROUGHOUT THE EMPIRE.*

BY

SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S.

INTRODUCTION.

I DO not intend to discuss the value of research in science, either in its bearing on general culture or in its more direct application to commercial industries. These were appreciated by many before the war and more widely, if still but vaguely, as the result of our shortcomings during the painful years which followed 1914.

The Prime Minister, in a recent speech in the House of Commons on unemployment, condensed a widely accepted view in the following words :—" No one will assert that British industry can be saved by science alone, but it is none the less true that until scientific methods and scientific men can take their place in industry, and an equal place with the administrator and the financier, British trade will never be strong enough or resilient enough to meet the shocks that it is bound to meet as the years go by, or to meet the sudden and unexpected changes which will always arise in international trade."

It is the problem of organizing research institutions, rather than the value of research itself that I have been urged to discuss in this address, and the problem falls into two natural divisions that are intimately related ; firstly, the evolution of a system of concerted action in Great Britain, and, secondly, the linking up of activities here with those in the Empire overseas.

Mr. Baldwin referred to the importance of applied science as an essential constituent of our economic armoury under peace conditions. We have had very painful illustrations of our industrial shortcomings during the war, but there is a phase of this question that has been less discussed, namely, the importance of making each large section of the Empire self-contained, not merely as an ordnance store, but as a manufacturing arsenal for essential munitions. The partial isolation of India and Australia during the last war gave us some idea of what will probably follow the greater development in the near future of submarine and aerial machines of war.

* Address to the Royal Society of Arts. Reprinted from the *Jour. Royal Soc. of Arts*, No. 3809.

We have also learnt three other matters of vital importance :—First, that nine-tenths of the articles and materials required by a modern army in the field closely resemble those that are essential to the maintenance of ordinary civil activities ; second, that the manufacture of all of them are problems of applied science ; and third, that often the interval between the laboratory and the workshop cannot be closed except by years of organized and expensive experiment on a large scale. The experimental work required for the commercial production of synthetic indigo cost over a million sterling and twenty years of hard work.

Organization on a national and even on an imperial basis is necessary, not merely to prevent unnecessary overlap of effort, of which, unfortunately, there has never hitherto been much danger, but to close the vulnerable gaps in our economic, and, therefore, military, defence works There is no institution or society in this country before which questions of this sort can be more appropriately discussed ; for no single voluntary society has done more than the Royal Society of Arts to extend the interest in science applied to industry ; and the illustrations that I intend to refer to in the sequel will show you that I am not indulging in even an approach to complimentary encouragement.

If I attempt to describe the many organizations that have been successful in stimulating the research work of specialists who are scattered throughout the Empire, the Secretary of the Society would find it difficult to get this address into a single " part " of the *Journal* ; if I referred even briefly to the failures, the Treasurer would refuse to pass our printers' bill. I propose to confine myself to a few illustrations to show in what directions co-operation can best meet the requirements of an Empire so widely scattered geographically ; so different in climatic and commercial conditions, and so varied in forms of administration and government.

Those who have made attempts to design and construct the machinery of correlation have had more things to consider than geographical and climatic diversity, or the rapid specialization and remarkable growth in bulk of the sciences. Planning to meet these complexities might be relatively easy if human nature were uniform and British science workers always docile. The main problem has been to give the local worker freedom in research activities, and yet at the same time get him to realize his obligations to the rest of the Imperial team.

VOLUNTARY SOCIETIES.

All movements in this country having for their object the correlation of activities in scientific research were, until the end of the last century, purely voluntary. " The Royal Society of London for improving Natural Knowledge," which is still the recognized leader, commenced its corporate life on the 15th July, 1662, and grew out of a small body, who, on the 5th December, 1660, made an agreement " to meete together weekely to consult and debate concerning the promoting of Experimental learning," each paying " one shilling towards the defraying of occasional charges."

Society of Arts.

The Royal Society in its earliest days included papers on technical and industrial subjects, as well as papers on pure science ; but its recognition of the applied side of science became insufficient to meet the demands which accompanied the industrial revolution and commercial expansion of the 18th century. The Society of Arts was consequently founded in 1754, and has, during the subsequent 171 years, maintained its position, without restriction of scope, as a voluntary association of those interested in turning the results of science in all its branches to account for the " encouragement of Arts, Manufactures and Commerce."

The curve showing the Society's expansion has occasionally steepened beyond its average slope, but has only once seriously sagged, and that was immediately preceding a period of rapid growth which was genetically connected with the evolution of our existing system for correlating research activities throughout the Empire. This period of remarkable activity was during the two decades following 1843, when the Prince Consort accepted the office of President, and took an active interest in the work of the Council until his death in 1861.

Two movements which were then originated by the Society have done more than any other instances of the sort that I can recall to stimulate national consciousness to the value of applied science, and both of these occurred in 1851—the Great Exhibition and the union of so-called mechanics' institutes, with its accompanying system of uniform examinations.

The success of the system of provincial examinations led to imitations, or rather specialized developments, which in their own way have been equally useful in stimulating the study of applied science, namely, those afterwards instituted by the Science and Arts Department and those commenced in 1879 and still conducted in technology by the City and Guilds Institute. The old Science and Arts Department served its purpose and gave way to other systems ; and the City and Guilds Institute has extended its influence to overseas parts of the Empire and now examines some 8,000 students annually.

In the control of examinations the Society, as in other activities, adopted the policy of standing aside in favour of each specialized organization. That it has been wise in thus curtailing its programme for the benefit of others, is shown by the later history of its examinations. Sir Henry Trueman Wood* expressed satisfaction that the numbers of our examinees rose from under 10,000 in 1900 to nearly 30,000 in 1913. It must be some satisfaction to him to know that his successor's burdens are not lightened ; for the examinees have since increased in numbers annually, and last year reached the heavy total of over 70,000.

I feel tempted almost, at this point, to break away from the subject which has been suggested to me by friends as the theme for this address, and to show you

* *A History of the Royal Society of Arts*, 1913, pp. 427 and 434.

by many like illustrations how the Society has grown in size and value, whilst encouraging the multiplication of its family of specialists by fission from the old parent. Neglect of the spirit which actuated our predecessors in this way has often in other non-specialized institutions been a drag on efforts made to effect a better organization of scientific research in the Empire ; but "that is another story."

The other outstanding enterprise which this Society, under the influence of the Prince Consort, undertook proved to be equally fruitful in useful by-products. Immediately following, and almost directly as a result of, the Great Exhibition of 1851 there arose "The Government School of Mines and of Science applied to the Arts," and this in 1863 became the Royal School of Mines, the oldest of the three institutions which were afterwards federated to form the Imperial College of Science and Technology.

Out of these two special enterprises on the part of the Society there thus arose the movement towards scientific and technical education leading to research, at first national and then imperial in its scope. It is interesting to notice that this last development, which required the shock of the war for us to take up seriously, resembles in a marked degree the very earliest activities of the Society. At its first meeting on the 22nd March, 1754, the Society decided to offer a prize for the growth of madder to displace the article then imported largely from the East and the Low Countries, and from that time onwards the *Transactions* record about an equal division of the Society's revenue between awards for inventions at home and agricultural work in the Colonies. The North American Colonies occupied most attention until their secession in 1774—attempts to encourage the production of silk, wine, potash, iron, hemp, pickled sturgeon, myrtle wax and wooden pipe-staves followed, in order, until the old records remind one almost of the Bulletins of the Imperial Institute. Then followed the attempt to transplant the bread-fruit from the Pacific Islands to the West Indies, resulting first in the Mutiny of the *Bounty*, but followed by Captain Bligh's success in 1793. Bread-fruit, because of the notorious *Bounty*, happens to be the one best known, but was only one of many—some successful and some otherwise- cinnamon, opium, indigo, cotton, camphor, quinine, tinctorial plants, and ornamental woods. Similar efforts were made to assist the development of the East Indies, Ceylon, Canada, the Cape and Australia. The office of the Society was for many years the principal channel of information between isolated workers in the Colonies and the scientific men and merchants at home.

I have referred to the two main phases of the Society's effort to turn science to account in industries of imperial as well as of national importance, because it is a striking instance of a characteristically British institution, maintained at the expense of its members for the benefit of the country and without the slightest financial assistance from Government. In 1856 the House of Lords called for a return of the sums of money granted by Government to the Society during the preceding five years. The answer then was *nil*, and so the subject was allowed to drop. That answer applies still.

National Institutions.

Efforts by private individuals were made early in the present century to make the country conscious of its dangers, but the results of such efforts were limited and fragmentary. The Imperial Institute, which was founded in 1887 to commemorate the jubilee of Queen Victoria's reign, was reconstituted in 1902 and transferred to Government in the hope that it would be able to assist more efficiently in the development of the natural resources of the Empire overseas. The National Physical Laboratory was established at Teddington under the control of the Royal Society in 1902, and its subsequent career of success, in which Sir Richard Glazebrook was the leading spirit, has justified the object of its foundation ; it has since expanded considerably, although the public money granted for its maintenance is still less than one-tenth of that devoted to its nearest American equivalent, the Bureau of Standards at Washington. The Imperial College of Science and Technology received its Royal Charter in 1907, and was founded " to give the highest specialized instruction and to provide the fullest equipment for the most advanced training and research in various branches of science, especially in its application to industry."

These are examples of the sporadic efforts which show that Government, even before the war, considered it necessary to develop national institutions for scientific research ; they even showed the dawning of an imperial spirit ; but it required the war, and with it the serious danger of imperial disintegration, to bring home to us fully three convictions ; firstly, that our inability to manufacture many essential munitions was due to the neglect of applied science in peace time ; secondly, that isolated instances of private enterprise must necessarily leave many gaps of vital importance in the programme of scientific work, and, thirdly, that some system of wider co-ordination was necessary to give effect to any political measures of a fiscal nature required to make the Empire relatively self-contained.

Research Department.

Ideas, however, developed quickly when the winter campaign of 1914-15 proved that the war was no ordinary military campaign, but was a competition to death of science and technology in an intensive form. Early in May 1915, the principal scientific societies, with the Royal Society at their head, urged on Government the importance of tackling our difficulties, and in June of that year the President of the Board of Education announced the decision of Government to establish a permanent organization for the promotion of industrial and scientific research, " which would operate over the kingdom as a whole and utilize the most effective means to the end in view irrespective of their locality. Since science and industry were both indifferent to political boundaries a single fund for the good of the United Kingdom as a whole was entrusted to a single authority—a Special Committee of the Privy Council," which was to work through an Advisory Council of distinguished scientific men.

The Advisory Council were directed to frame a programme for their own guidance in recommending proposals for research and for the guidance of the Committee of Council in allocating such State funds as might be available. According to the Order in Council, it was realized that the scheme would naturally be designed to operate over some years in advance, and in framing it the Council would necessarily have due regard to the relative urgency of the problems requiring solution, the supply of trained researchers available for particular pieces of research, and the material facilities in the form of laboratories and equipment which were available or could be provided for specific researches. Such a scheme would naturally be elastic and require modification from year to year; but it was obviously undesirable that the Council should live "from hand to mouth" or work on the principle of "first come first served," and the recommendations should thus represent progressive instalments of a considered programme and policy.

The new Advisory Council decided to give science in its application to industry precedence over pure science in their deliberations. They found that certain researches which were conducted by professional associations in the period preceding the war were in danger of abandonment, and they decided to assist these by special grants. They conferred with the specialized associations, societies and institutions of science and technology and formed a register of the researches which were being conducted in educational institutions on the outbreak of war, and they attempted to facilitate the resumption of these by financial assistance and by recovering when possible specialists who were with the new army in the field. They formed special Committees for various branches of applied science, in order to get the best advice regarding the investment of public funds and the necessity of new enterprises.

It is impossible in a short address to describe or even to enumerate the various activities of the new Department of Scientific and Industrial Research which thus started in 1915 and continues still, with the help of its Advisory Council, to carry on a work of co-ordination, which, if instituted before the war, would have saved many lives and have reduced our consequent financial burden.

What the Department has done and is doing is set out plainly in its Annual Reports; they show that at last we have the machinery which will prevent unnecessary overlap as well as the far more important matter of closing up, as fast and as thoroughly as practicable, the dangerous gaps in our development of applied science. What was before an amorphous mob of scientific workers is now approaching the form of an organized army, without, however, inhibiting that freedom and individuality which is essential to every research worker; and the Department does not attempt to do itself what can quite well be done in established colleges, universities and other institutions. This phase of its policy has an important bearing on the question which I propose to discuss in the sequel.

There is abundant room still for expansion, and there are opportunities for spending economically far more than the annual half-million that the Department

now disburses ; but the progress of research to be healthy is limited by various difficulties that will take time to remove. Among other things, research workers are not manufactured by mass production. Only a fraction of those who get a scientific education are suitable, and even these cannot now be absorbed readily by firms who are suffering from the general depression of our technical industries.

Overseas Organizations.

The institution of the new Committee of the Privy Council on the 28th July, 1915, was quickly followed by a suggestion that the scheme intended for the United Kingdom should be extended and made applicable to the Dominions and even to the Empire as a whole. The proposal in definite form came from Australia ; where it originated with a memorandum by the Public Works Minister of Victoria. The Committee of the Privy Council here backed the suggestion by a memorandum which might be read advantageously to Parliament every time it assembles. Its appreciation of the value of applied science when the sky was overcast with war clouds reminds one of Kipling's contrast between the respect we show Tommy Atkins in peace time and what we think of him " when the drums begin to roll."

The Committee pointed out how the Australian suggestion could be turned to practical account, with the establishment in each Dominion of an authoritative body like that established at home ; they showed how an organization of the sort would react on the educational work of the universities in which the research workers are mainly trained, and they indicated the necessity of having in London some sort of clearing house and information bureau.

The Dominions and India promptly set up central authorities corresponding approximately to the new Committee at home, and the evolution of these is summarized in the Annual Reports of the Department. It is not necessary to repeat the details in this address, but, as the result of the correspondence and of later Imperial Conferences, various developments of great importance followed. In the first place, instead of having in London a general Bureau of Information, it was considered desirable to establish specializedBureaux by Imperial co-operation, and various subjects were considered to be suitable, such as agriculture, statistics, mycology, and minerals. For entomology an organization existed before the war and its obvious success encouraged the hope that the idea was capable of extension. Before the reaction of peace and the subsequent economic depression affected Government as well as commercial firms, separate Imperial Bureaux had already been started for Minerals and Mycology, and these deserve more than a passing notice ; for they justify the belief that the system might be extended to other branches at a cost that forms a very small fraction of their value, to overseas workers specially.

CIVIL RESEARCH COMMITTEE.

The Research Councils and corresponding central authorities under other names in India and the Dominions underwent changes after the cessation of war, and the developments which have occurred form very interesting object-lessons for students of administration. Before speaking of these, of the Imperial Resources Bureaux in London and of other attempts to build and furnish the superstructure, I should like very briefly to refer to the way in which the Government at home have very recently attempted to complete the framework. This latest decision shows, at any rate, that the seed which was sown in 1915 did not actually die during the post-war financial drought.

In the House of Lords on the 20th May last, Lord Balfour announced the intention to form a sort of super-committee, the Committee of Civil Research, analogous in principle and functions to the Committee of Imperial Defence, and, like it, to be Advisory Body with no administrative and executive functions. This Committee, over which the Prime Minister will preside, will be charged with the duty of giving connected forethought from a central Imperial standpoint to the development of economic, scientific and statistical research in relation to civil policy and administration. It will also indicate new areas in which enquiry might profitably be undertaken.

On the analogy of the Committee of Imperial Defence, this new Committee will not be constant in composition, but may include, as and when required, specialists both private and official. It will deliberate on questions that cannot by themselves be dealt with by any single administrative department of Government, and it will thus form a responsible and authoritative medium of correlation in a way that would not be possible for any junior or voluntary association. There are many branches of science outside the scope of the new Research Department, which was formed mainly to supervise the activities in those branches that before touched many departments independently.

I have now dealt in outline with the general scheme of organization — its origin, its foundation and the framework of its superstructure. It is important to inspect more closely samples of the infilling. The most important of these are :—

(1) The Imperial Information Bureaux in London.
(2) The Trades Research Associations, and especially the largest of them, the Empire Cotton Growing Corporation ;
(3) The Research Councils, or corresponding authorities, in India and the Dominions ; and
(4) The Specialized Institutes here and overseas.

(*To be continued.*)

THE DIRECT METHOD IN THE MICROBIOLOGICAL STUDY OF THE SOIL.*

BY

S. WINOGRADSKY.

[*Translated by Professor N. Gangulee, University of Calcutta.*]

(Concluded from *Agri. Jour. India*, XXI, p. 139.)

Sir John Russell's Opinion.

I will not hide the fact that the above opinions are not very widespread amongst microbiologists, but I am happy in not feeling alone. I read quite recently the text of a lecture delivered by Sir John Russell at the Third Congress of Industrial Chemistry, and I found there a passage which it gives me great pleasure to quote in full.

"The only organisms," says the English scholar, "concerning which we have any definite ideas, however slight, are the fixers of nitrogen and the nitrifying organisms. According to our present knowledge the organisms of the nodules .... and the organisms of Winogradsky and Beijerinck, living at large in the soil, alone have the power to fix appreciable quantities of nitrogen, and the three organisms of Winogradsky alone can oxidize ammonia to nitrite and then to nitrate. We cannot," continues he, "speak with certainty of any other organisms, any more than I see at present the way to discuss the action a given group of organisms would have in the soil. If our French colleagues can discover some method to study this, they will render a great service to science."

Case of the Azotobacter.

Thus, Sir John Russell, eminent and wise scholar that he is, considers of all the collection, only the *fixers of nitrogen* and the *nitrifying organisms* as being genuine. The semi-parasitic nature of the root organisms naturally puts them out of consideration in the question which concerns us. *The fixers of nitrogen and the nitrifiers*, which exist in the soil, now remain to be dealt with. Of the identity of the latter, we agree, there is no doubt. Even in this exclusive case, however, it would be difficult to deny the possibility of the formation of new races in our culture-tubes. As regards the fixers of nitrogen, such as the *Clostridium* and the *Azotobacter*, we will not go so far as our English confrere.

* The original appeared in *Chemie and Industrie*, Vol. XI, No. 2, 1924.

We ask ourselves whether these definite fixers of the laboratory are such in nature, and if this fixing activity is as important as that which is attributed to them without sufficient proof.

This question arises chiefly with regard to the *Azotobacter*, the great favourite of modern agricultural microbiology. Personally, we are inclined to believe in its interesting rôle, although at present we cannot prove our point. In order to do so, it would be necessary to follow more closely the way in which it behaves in the soil, to see if it is able to convert to its own use the energising matter which is offered, and to multiply by trampling down and outstripping its foes, for it is only by this means that it could exercise any appreciable influence. At present nothing is known about this. It has very often been found in the soil, it is true, but this tells us nothing as to its numerical force. The current practice is, then, to throw one or two grammes of earth, or even more, into a liquid containing mannitol, to start the first culture. One can see the characteristic "veil" form, and from this its presence in the earth is concluded. This procedure gives no indication as to the number of bacteria, for only a few bacteria per gramme, be they in the active, or even in the inactive state, are required to start multiplication in the nutrient liquid. It is found in the soil may be, but if it only exists there in small numbers one should have no right to attribute to it an important rôle. Nothing is known about it, we repeat, in spite of the vast literature which treats of its morphology and physiology.

Our picture of the present state of our science is now, we consider, almost complete. Our criticism, contrary to the old saying, has not been easy, and it leads us to the following pessimistic prognosis: *If we retain the present method, we shall never succeed in studying the rôle of the soil bacteria in their natural medium, though these experiments in pure culture were to continue for ever.*

REMY-LOHNIS METHOD.

Before speaking of a new method, let us rapidly review a few attempts, rather vague, it is true, but evidently inspired with the idea of putting microbiology more directly at the service of the science of the soil. Thus it has been proposed to replace pure cultures by the so-called synthetic mixtures of bacterial species with the aim of imitating the natural medium, an idea impossible to attain for reasons easy to understand.

Another, the Remy-Lohnis method has been thought to approach natural conditions by introducing more earth than is customary—up to 10 per cent.—in the appropriate solutions, in order to study therein the processes set in action, and to correlate these with the fertility of the earth employed. It is, however, difficult to explain its procedure and its ends.

Was it desired to activate the bacteria by introducing more earth into the solutions, or merely to mix them with the constituents of earth? The reply is not clear. What is clearly seen is that a layer of earth, drowned in so much liquid, reproduces

only the conditions of a pool, which differ essentially from those of a sound soil. Also, all the conclusions one is forced to draw from these experiments have had only an uncertain character, and we consider that this method should only be mentioned in passing.

THE DIRECT METHOD.*

I will now present a rough draft of the method that I have adopted, and which deserves, in my opinion, the name of the "direct method," for it allows bacterial phenomena to be studied under conditions imitating natural conditions. I would scarcely say that it is perfect as a technique at present. All that I have asked is permission to take the first steps on the road of direct experiment which for so long has appeared to be closed.

I have already had occasion to point out the difficulties which the soil medium puts in our path. First of all, there is the difficulty of microscopic examination, lying principally in the lack of a method of preparation which would differentiate well between the bacteria and the waste of all kinds, and above all, between them and the granulations of the gel. Secondly, there is the very great heterogeneity of its population and hence the risk of becoming muddled.

The first tentative experiments were directed against these two points, for evidently it is not possible to see into the earth-medium. If, on the other hand, it were

* During his visit to the Institute of Pasteur near Paris, the translator had the honour of meeting Professor Winogradsky, who kindly explained to him the technique involved in the direct method of studying soil bacteria. Recently a short account of this method has appeared in *Comptes rendus des Seances de l'Academie des Sciences* (Vol. 179, p. 367), from which the following details are extracted :—

1 grm. of finely divided soil, taken from a well mixed sample, is thrown into 4 c.c. of distilled water and shaken in a standard manner for 5 minutes. It is allowed to settle for 30 seconds, and the suspension is decanted from above the deposit into a small hand centrifuge tube. Two successive lots of 3 c. c. of water are added, each being shaken for one minute, allowed to settle for 30 seconds, and finally decanted into the same tube. Thus 10 parts of water in all are used for one of soil. After these three washings the first deposit when resuspended in water settles rapidly, leaving the water clear. During the manipulation, which lasts about 10 minutes, a deposit is formed in the centrifuge tube without interfering with the latter, half the supernatant liquid is run into a second centrifugere tube. The two are then centrifuged until the supernatant liquid ceases to become clearer. Ordinarily, 100 to 200 turns of the handle are sufficient. There are then three deposits and two different suspensions, one having been centrifuged and the other not. Five preparations of them are made at a convenient time, using approximately the same quantities of the deposits and liquids and spreading them on equal surfaces of slides. When the soil is dry it is necessary to bind the largest particles in the first and second deposits to prevent their becoming detached. One per cent. agar used warm is most useful for this purpose. For the third deposit, and sometimes for the second, a 0.1 per cent. solution used cold is sufficient. For preparation of suspensions which contain a basis of colloidal matter encrusted with minute particles, any fixitive is unnecessary. After drying again the slides are treated with absolute alcohol for 1 to 2 minutes; they are dried and stained. In selecting a stain we adopted M. Conn's happy idea of using an acid dye dissolved in dilute carbolic acid. But we prefer Erythrosin to all others. We believe that this dye is destined to render most service in the microbiological study of the soil. It differentiates the bodies of microbes perfectly, leaving the gelatinous capsules which envelop the soil particles colourless, in this way making it possible to distinguish the structure of the latter. It may be washed from the soil colloids, and the fixitive used by means of water; and if microscopic flakes or grains are found which are not decolorized completely, particularly in the soil, their tint is never scarlet red like microbe cells, but of a quite pale brick red or salmon colour. The manipulation is of the simplest kind; allow the stain to act in the cold for 5 to 15 minutes, wash in water, and examine in water,

not possible to distinguish between the multitude and variety of the organisms, the difficulty would be insurmountable. Happily we were soon assured that such was not the case.

USE OF ACID STAINS.

For the process of microscopic preparation, several acid stains differentiate well between the different vegetable forms but not between the spores, by leaving the gel of the soil uncoloured. This is already an encouraging result. I will even say that, for the moment, it is sufficient for us to be able to prove the presence, and even, for certain species, the number, in the state which interests us the most, that is to say, in the active state. It is, above all, the action that is of importance to us; of this the spores are certainly destitute, representing only potential faculties which we will otherwise take count of in our experiments.

CHOICE OF THE SAMPLE OF EARTH.

As regards the bacterial population, in order to avoid too great an excess it was evidently advantageous to choose as a foundation of the experiment a poor soil that for a long period had received no substance which could have stimulated the multiplication of bacteria. This earth could be relied upon to maintain itself in a sufficiently stable state of biological equilibrium to permit it to fix its character from the point of view of the species which inhabit it and of their numerical force. For the purpose, a sample of ground was chosen from a plot of very old cultivation, which has remained for years without manure, had received no recent dressing and had no vegetation.

By a careful microscopic study of this earth repeated several times—each repetition serving as a control—it was proved that it contained only a very restricted number of bacteria, belonging only to three or four types of *Cocci*, the elegant little colonies, brilliantly coloured, of these being seen lodged on the particles of gel. A few small groups of unquestionable *Azotobacter*, small mycellia of *Actinomycetes*, and a few isolated yeast cells, completed this scanty micro-flora. There was absolutely no sign of bacilli or moulds.

PROCEDURE.

It is now all-important to follow the manner in which this earth reacts against all attempts of nature to destroy its biological equilibrium. The natural method of doing this is, evidently, to mix with it some organic substance capable of acting as a source of energy for the bacteria. Several have been tried and one has been struck by the intensity of the changes produced. These changes may be described as follows:—All at once, one species, or a little group of species which are functionally

related, enter the scene and multiply greatly, over-running all the rest, which remain stationary as regards number. *In this manner, the species or group immediately takes our attention as having found, in the given conditions, the correct environment for its functioning, as determined by the energy material supplied.*

Auxiliary culture.

We will give, by-and-by, some characteristic examples. Let us first of all mention a second procedure intended to complete and support the results of microscopic examination ; this is the method of *auxiliary cultures.* These are plates of a gelatine medium in Petri dishes, inoculated sometimes by minute particles of earth and sometimes by different suspensions. The solid medium is essential. The liquid medium, on the contrary, is to be rigorously proscribed in this case, for biological relations which characterize the healthy soil are there so distorted as to become unrecognizable. As regards composition, these solid media must correspond as much as possible to the soil medium, that is to say, they must contain the same energising substance, and practically in the same amount, as well as a proportion of assimilable nitrogen of the same order.

Biological state and reaction of the earth.

By employing these two methods—microscopic examination of the earth and auxiliary culture—in a strictly parallel manner, we have succeeded, in the case which we have been able to study up to the present, in determining the *microbiological state* of the soil and its reaction. By microbiological, or more simply, *biological state* we mean the quality and quantity of the active bacterial cells which it contains. *Biological reaction* is the term applied to the multiplications which have been stimulated in the medium by the energising substance. It would be useless to emphasize the importance of these characteristics, especially if one succeeds in determining them in the majority of cases.

We can scarcely doubt that the bacterial multiplication is closely bound to chemical processes and that it is essential to carry on the study by means of parallel analyses of the *earth-culture* on one hand, and of the *test earth* on the other. These analyses give sufficiently exact results, provided, of course, that the experiment is interrupted at the critical moment. For, we consider that the different states or reactions can follow each other with fair rapidity ; the experimenter must therefore take care to seize the correct moment to fix the chemical effects of the biological reactions. On the other hand, if the successive phases are allowed to superimpose, the results will become difficult to interpret, especially in the present state of our knowledge. This would be the case even with definite chemical substances, without speaking of crude chemical substances of animal and vegetable origin whose turn will naturally come later.

These are the essentials of the direct method which I propose. I hope that I have proved that it brings the experimenter as near as possible to natural conditions. By using it, he is able to observe the soil bacteria in their natural medium and if it is carried out with cultures on an artificial medium, it is only to be better able to view the *bacterial field.* This is more imposing when it is uniform ; that is to say, when both the earth and its auxiliary plate are found to be invaded by a single species, but even when the film is varied, it is more instructive, we, believe, in our case than an assembly of pure cultures.

I feel that I must now describe a few experiments, still unpublished, to illustrate the principles I have put forward and to give a more vivid idea of the method of work.

Experiments with nitrogenous bodies.

Let us, then, look at fresh soil from the portion taken from the old kitchen garden of Brie-Comte-Robert. Its biological state is known to us. If necessary we shall recontrol it. When gently sifted and brought to the degree of humidity and the capacity desired, it is ready for the experiment. Let us now mix an energising substance with it, and let us choose one gramme of peptone, a protein, to begin with. Put the mixture in an incubator at 30°C. for one night only. Examine it in the morning without delay, and at once inoculate auxiliary plates. The earth which yesterday showed no evidence of bacterial life is now crowded. Thousands of individuals cover the whole field of vision of the preparation. Their number may be estimated without fear of error at ten thousand million or more.

The field which the film presents are of colonies of *two kinds* only, these being bacilli. In both, they have invaded the whole film, and nothing but them can be seen there. It is true that we have waited for plentiful reproduction, but, all the same, one is struck by its spontaneous character, and the degree attained, but above all by the fact that only two species of bacilli of analogous function have invaded the soil to the exclusion of all others, and that in spite of the well-known fact that peptone is the favourite food of a multitude of bacterial species. The struggle of the bacteria in the soil has decided that these two species only should succeed in taking the lion's share.

We must add that the reaction is scarcely permanent, but comes to an end after some thirty hours. The victorious bacilli are for the moment at the end of their career, and there remains of them only a heap of spores awaiting the return of favourable circumstances.

Let us now take urea and add it in the same amount to our earth. At the end of twenty-four hours it has already begun to evolve a smell of ammonia. On the Petri auxiliary cultures two different bacilli have invaded everything, thrusting themselves forward as the urea ferments they are. The remainder of the soil bacteria do not change, and that again despite the well-known fact that urea is a good nitrogenous

food for numerous species. Evidently, however, there are only two that have found their optimum conditions, perhaps by paralysing the others, by the strong evolution of ammonia.

EXPERIMENTS WITH CARBOHYDRATES.

Let us now pass on to carbohydrates, and recall at once that in addition to these, assimilable nitrogen is required to supply the alimental needs of any organism whatsoever. We can foresee that the ratio of the nitrogen, or more exactly its proportion to the carbohydrate substance, is bound to have a marked effect on the biological reaction. Indeed we are confident that we have here an interesting series to study in all its details.

One of the most interesting cases is that of the minimum ratio which our dried earth offers us. In spite of this elective condition, the reaction remains intense, and more, it appears different according to the energetic substance added. If it is a starch it can be seen rapidly disappearing, while the earth becomes enriched with a particular bacillus and with mycellia of *Actinomycetes*. On the Petri auxiliary cultures—on a starch—impregnated gelatine—it forms around broad zones of vegetation, which no longer turn blue with iodine, thus bearing witness to a starchy energising power. If it is a pentose, other organisms appear. If it is a cellulose we see principally the mycellia of certain *moulds*. Without describing all these observations now, we can say that they inspire us with the hope of one day being able to arrive at a complete process of biological analysis of the soil, the importance of which cannot be demonstrated.

Let us maintain this minimum ratio of nitrogen by adding to a poor soil, glucose, or better still, mannose: this time we have *Azotobacter* entering the field. Their presence in our soil had already been proved before the addition of mannose, but in very small amount. In the earth containing mannose, they alone commenced to multiply. At the end of two or three days their numerical force reached two hundred millions per gramme of earth. If a furtherhalf gramme of mannitol is added, vegetation begins again, but without any other types appearing, and reaches three hundred and fifty million individuals per gramme of earth which give a substantial mass of bacterial substance, these bacteria being of great size compared with other species.

Now let us raise the humidity of the soil, and, omitting for the time the intermediate stages, arrive at once at complete submersion. One night in the oven is sufficient to make the earth to overflow, it is lifted up by large bubbles of gas and gives off a butyric odour. At first sight one recognised the *Clostridium Pastorianum*, the butyric ferment of the soil. It was certainly in the original earth, witness the rapidity and sudden intensity of the fermentation ; but it was there in the state of spores, invisible and inactive. It scarcely counted until the time that it was given its suitable environment, and then it took the leading part.

Effect of the proportion of nitrogen.

Here is a last, rather instructive experiment: let us gradually raise the proportion of nitrogen in our mannose-earth by adding nitric nitrogen. Let us remember that the *Azotobacter* is greatly aided in pure culture by small amounts of this nitrogen and gives very luxuriant cultures. We will see what will happen in our natural medium. In the earth with two parts of nitrogen to a thousand of mannose the *Azotobacters* multiply *less* than in mannose earth without the addition of nitrogen, and almost half: their number attains only a hundred and twenty millions per gramme of earth. At five to a thousand there are only three millions; that is to say, mutiplication has already commenced to stop. At seven to a thousand and at ten there is no trace of the *Azotobacter*. Other organisms appear, evidently adapted to the particular nitrogen-carbohydrate ratio. Curious things happen, as for example, this: At seven to a thousand, spontaneous reproduction of a very small bacterium, whose number counted exactly reaches three milliards, six hundred millions per gramme of earth, takes place. This, however, is totally absent at five to a thousand, and at ten, when other types predominate.

All these observations show that it is not the inherent qualities of a bacterium which determine its rôle in the soil *but it is the struggle of the cells with these hardships which is the principal regulator of the cycle and the distributer of the bacterial activity.* In the case of the *Azotobacter*, paralysed in the earth by the very small addition of nitrogen, we can very well conceive, from this point of view, that a substance or condition, in itself useful or favourable to the bacteria, becomes just the contrary when it favours the numerous and powerful enemies which are ever on the watch to suppress or kill them.

Rapidity of the reaction.

What is still a very interesting characteristic of the earth is the rapidity of the process set into action by the energising substance. The long incubation periods to which the microbiologist is accustomed in dealing with pure cultures is reduced to so short a period that it is scarcely noticed. An *energised earth*—if I may be permitted to use the term—starts off with the greatest ease. The reaction starts with a rush and goes rapidly to the end. It does not appear to us difficult to find an explanation of this fact.

The soil, reservoir for all the waste, debris and corpses of countless ages, is a medium which harbours all the bacteria imaginable. The majority of these are, at a given moment, in the state of latent life, only a minority being in the active state. The earth sheltering the bacteria from light and dryness keeps them in the best possible conditions, and since the number of these germs is always very great, the incubation period is almost suppressed; the germination at 30° taking only a short time, the medium is at once populated by the species which are the most active under the given conditions.

Further developments.

One could say that the bacterial processes in the soil are composed of a multitude of phases which come into play, each bound to the action of a single agent or of a group of bacterial agents. These phases are often ephemeral; but the microbiologist must take them on the wing if he wishes to understand the activity of bacteria in the soil.

That is to say, that along with present-day microbiology, which may be called *static*, our branch must inaugurate, in some way, a *dynamic microbiology*, without which we believe it impossible to arrive at the solutions of the questions which deal with the science of the soil.

This will be an immense work. We have only to consider the immense number of different substances offered as a prey to the soil bacteria, of the innumerable combinations of concomitant conditions, of soils so different from the mineralogical, chemical and physical points of view, of different climates, etc., to realize this.

But when, with the collaboration of the different workers, this work is sufficiently advanced, then, and only then, can we speak of agricultural microbiology as an established science, whose importance to agriculture cannot be over-estimated.

NOTES

MAYNARD GANGA RAM PRIZE FOR DEVELOPMENT OF AGRICULTURE.

Sir Ganga Ram, Kt., C.I.E., M.V.O., R.B., Lahore, with that generosity for which he is now so well known, has handed over to the Punjab Government a sum of Rs. 25,000 for the endowment of a prize to be awarded for a discovery, or an invention, or a new practical method which will tend to increase agricultural production in the Punjab on a paying basis. The property has been vested in the Treasurer of Charitable Endowments for the Punjab and is to be administered by a Managing Committee consisting of—

1. The Vice-Chancellor of the Punjab University (Chairman).
2. The Agricultural Adviser to the Government of India.
3. The Registrar, Co-operative Societies, Punjab.
4. Sir Ganga Ram, and after him a nominee of the Sir Ganga Ram Charitable Trust.
5. Sir John Maynard during his lifetime.
6. The Director of Agriculture, Punjab (Convener and Secretary).

The interest accruing from the property shall after such deductions as are authorized by the rules framed under the Charitable Endowments Act, 1890, be payable by the Treasurer of Charitable Endowments to the Managing Committee.

The prize is to be known as the Maynard Ganga Ram Prize and is to be awarded every three years provided a satisfactory achievement is reported to the Managing Committee. It will be of the value of Rs. 3,000 approximately and the competition will be open to the world.

Applications for the first award should reach the Director of Agriculture, Punjab, by the 1st of January 1929.

THE ELIMINATION OF GERMS FROM DAIRY UTENSILS.

In "Bulletin No. 254 of the University of Illinois Agricultural Experiment Station," Prucha and Harding give the results obtained in an exhaustive series of experiments concerning the effect of steaming milk cans over a jet on the numbers of bacteria in the cans.

One thousand three hundred and forty-eight cans were examined. All the cans were washed, and a random selection of 191 cans was examined, a few each

day, before steaming. The bacterial content of these cans varied enormously, but the average increase in germ content of milk filled into such cans would have been 83,400 bacteria per cubic centimetre.

No information as to the number of bacteria a can might be allowed to add to milk and still be considered satisfactory, was available, and replies to a questionnaire sent to 250 representative health officers, milk dealers and dairy scientists showed considerable difference of opinion, but the most common view was that a can may add up to about 100 bacteria per cubic centimetre and still be considered satisfactory.

The data obtained from the examination of 1,157 steamed cans showed that for an 8 gallon can at least 9 cubic feet of steam were necessary in order to produce a can which, upon being promptly filled with milk, will not increase the bacterial count of the milk by more than 100 bacteria per cubic centimetre.

To allow a proper margin of safety, the amount of steam used should be 12 cubic feet.

The table shows the times and pressure necessary to force 9 to 12 cubic feet of steam through a jet opening ¼ inch in diameter. The amount of steam varies directly with the area of the jet opening.

Time Seconds	Pressure lb.	Steam cu. ft.
10	35	9·100
15	20	9·438
15	25	10·920
20	15	10·374
20	20	12·584
25	10	10·348
25	15	12·948
30	10	12·402
35	5	9·464
60	3	9·984

The authors consider that in practice the most satisfactory results are obtained when the flow of steam is so controlled that it requires from 15 to 30 seconds to blow into each can 12 cubic feet of steam.

It must be clearly understood that this amount of steaming produces a can that is satisfactory only if it is to be used at once. If the can is left in a moist condition in a warm place for a few hours, the surviving bacteria increase and multiply to such an extent that the can becomes unfit for the reception of milk. [J. H. W.]

POINTS ABOUT PIT SILOS.

THE following extracts from a paper read at a Conference of Agricultural Instructors of the Department of Agriculture, Sydney, by Mr. B. M. Arthur, are reprinted from *Agricultural Gazette of New South Wales*, XXXVI, Pt. 8 :—

In times of drought it is a moot point whether the pecuniary loss to the man on the land, be he farmer, dairy-farmer or grazier, is not greater in the aggregate from the loss of stock by feed and water shortage than by crop failures. In the case of a failure of the staple crop, the farmer is only out of pocket to the value of seed and manure used, horse feed, and time lost, but where stock, such as sheep, horses, and cattle, die from starvation the monetary loss is a real one and replacement often difficult, even if the person concerned has the necessary wherewithal to purchase his requirements—in which case he has not the Rural Industries Branch to assist him.

Ensiling crops in pits is indisputably the cheapest and easiest form of fodder conservation, excepting perhaps the storage of grain, and it has the added advantage that the fodder is safe from fire and mice damage. As silage is not usually a saleable commodity, the owner is not tempted by the offer of lucrative prices to sell, as is often the case with stored hay or grain.

Several farmers and graziers in the central west put down and filled pits during the past season in localities such as Wellington, Dubbo, Narromine, Peak Hill, Gilgandra, etc. It seems only necessary to prevail on one or two individuals in each locality to put down and fill silage pits, and, with the advent of a dry time, the advantages of having stored silage will be realized by neighbours. It is usual to find silage-makers in groups, one man having perhaps commenced some years ago and the others having followed suit on realizing the success of the method.

By conversation with men who have filled pits for some years, and by personal observation, several points in connection with the work of filling and emptying pits have appealed to me as being possible improvements over the usually accepted methods.

It is noticeable that the general tendency of the novice in silage-making is to make the pits deeper and wider than is advisable. In fact, one case came before my notice recently of a farmer who had excavated a pit 10 feet square and 10 feet deep by pick and shovel, and knew of no other way until put on the right track. But experience soon teaches that deep pits increase the labour of filling and emptying, and the trend of the experienced is towards even shallower pits than is usually recommended, and the quality of the silage turned out seems to be good. The excavation is usually carried out by the owner himself, but several cases have come before my notice where pits have been put down by contract at from 1*s.* to 1*s.* 6*d.* per cubic yard.

Wheat, oats, or barley are generally used, but in one case last season silage was successfully made from a mixture consisting mainly of variegated thistles. My

advice was asked by a farmer who had sown 10 acres of lucerne on the Macquarie River flats as to how he could best get rid of a tremendous crop of thistles which had come up with the young lucerne plants and which was threatening to kill out the lucerne by excluding the sunlight. This thistle crop was estimated to be at least 10 tons per acre. I suggested that he would kill two birds with one stone by cutting the thistles and lucerne with a mower while green, and putting the mixture into a silage pit. As there was a possibility that the material would be too sappy and become mushy, about 10 acres of a wheat crop was cut and put in with the thistles, in the proportion of one load of wheat to two of thistles. The resultant silage has proved to be excellent.

Most of the cereal crops are cut with a binder. There are differences of opinion as to the best methods of filling the pit. Some advocate putting the sheaves in crossways, the contention being that it makes for easier work in emptying, as one is able to pull the sheaves out whole by the binder twine band. The method does not appear to affect greatly the settling-down of the material.

A good point that came under my notice, and that was gained by experience by two silage makers of several years standing, is that in building up the pit above the ground-level the height should be made to correspond to the depth of the pit, *i.e.*, where the pit is, say, 6 feet deep, the material should be stacked 6 feet high, and it is then sloped off accordingly to the slope of the batter. It has also been found that there is often a tendency for a shrinkage of the material away from the walls of the pit, allowing the covering earth to crack and open and permit run-off water to get down the sides during rain; this, together with the air so admitted, tends to spoil a greater percentage of the silage than is usual in well-filled pits. In order to avoid this, the plan of overlapping the sheaves about 6 inches over the sides of the pit when building up above the ground level has been adopted. Then the main mass of the material, on settling down by its own weight, drags this overlapping material in and down the sides and thereby prevents any undue shrinkage away from the walls.

A method of lessening the work when covering the material with earth was gleaned from two or three silage-makers. When topping off the portion stacked above ground-level, it is built somewhat similar to a haystack, and a final double row of sheaves is overlapped along the ridge. The earth excavated from the pit is first dumped along this ridge by means of a bucket scoop, putting sufficient on to bind the mass thoroughly, taking the earth up from the ends. Then the balance of the covering is done from the sides, commencing at ground level, and putting each successive scoop full on top of the preceding one, working from each side alternately until the material is covered with a sufficient layer of earth. This method tends to make the work of covering the pit less tedious than when all the earth is taken up from the ends, which is the usual method adopted.

FUMIGATION OF AMERICAN COTTON IMPORTED INTO INDIA.

In pursuance of clause (*c*) in paragraph 2 of the notification of the Government of India, Department of Education, Health and Lands, No. 1493-A dated the 14th November 1925 (*Agri. Jour. India*, XXI, p. 154), the Governor-General in Council is pleased to fix the rate at which the sum therein referred to is to be paid at Rs. 3-6-0 per bale, or in cases in which the importer has failed to furnish information in accord with clause (*a*) in paragraph 2 of the said notification at Rs. 5-6-0 per bale. This rate shall cover the cost of fumigation including the cost of loading the cotton into the barge, conveyance to the fumigation wharf or bunder, unloading from the barge after fumigation and delivery at the bunder, but not including docks import charges as specified in the Bombay Port Trust scale of Rates charged at the docks. Provided that the minimum fee for the fumigation of any consignment of cotton shall be Rs. 150.

2. In the case of samples of American cotton imported by parcel post, or as ships parcels not exceeding 20 lb. each in weight, the consignee shall pay a fee for fumigation of Rs. 2 for each parcel.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

Mr. P. V. Isaac, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist), Pusa, has been granted combined leave for six and a half months from 26th March 1926.

Mr. Nand Lal Dutt, M. Sc., has been appointed Second Cane-breeding Officer at the Imperial Sugarcane Station, Coimbatore.

Mr. F. Ware, F.R.C.V.S., Professor of Medicine and Principal, Madras Veterinary College, has been appointed to officiate as Director of Imperial Institute of Veterinary Research, Muktesar, *vice* Mr. J. T. Edwards on leave.

Mr. D. A. D. Aitchison, M.R.C.V.S., has been appointed Veterinary Adviser to Government, Madras, on return from leave.

Mr. P. T. Saunders, M.R.C.V.S., Acting Principal, Madras Veterinary College, has been granted leave on average pay for five months from 1st July, 1926, with permission to combine it with the vacation for three months commencing on 1st April, 1926.

Mr. F. Smith, B.Sc., has been appointed to act as Assistant Director of Agriculture, Bengal, *vice* Mr. K. McLean on leave.

Mr. A. P. Cliff, B.A., Deputy Director of Agriculture, Chota Nagpur, has been granted leave on average pay for eight months from 25th February, 1926.

MR. C. A. MCLEAN, M.A., B. SC., Deputy Director of Agriculture, North Bihar, has been transferred in the same capacity to Chota Nagpur.

MR. BENI MADHAB CHATTERJEE, Assistant Director of Agriculture, Purnea, has been appointed to act as Deputy Director of Agriculture, North Bihar, in addition to his own duties until further orders.

MR. D. QUINLAN, M.R.C.V.S., Director, Civil Veterinary Department, Bihar and Orissa, has been granted leave on average pay for eight months from 7th April 1926, Captain P. B. Riley Officiating.

MR. G. CLARKE, F.I.C., Director of Agriculture, United Provinces, has been granted leave on average pay for six months from 20th April, 1926, Dr. A. E. Parr Officiating.

MR. C. MAYA DAS, M.A., B.Sc., Officiating Principal, Agricultural College, Cawnpore, has been confirmed in the appointment from 22nd December, 1925.

MR. D. P. JOHNSTON, A.R.C.Sc.I., N.D.A., Deputy Director of Agriculture, Punjab, has been placed in charge of the newly created Montgomery Circle in the Lower Bari Doab Canal Colony.

MR. F. J. PLYMEN, A. C. G. I. Director of Agriculture, Central Provinces, has been granted leave on average pay for seven months and four days from 26th March 1926, Mr. R. G. Allan Officiating.

MR. A. MCKERRAL, M.A., B.Sc., Director of Agriculture, Burma, has been granted combined leave for nine months from 1st April, 1926, Mr. T. D. Stock Officiating.

On return from leave, MR. H. F. ROBERTSON, B.Sc., Deputy Director of Agriculture, Burma, has been posted to the Myingyan Circle, *vice* Mr. T. D. Stock on other duty.

MR. R. WATSON, N.D.A., Deputy Director of Agriculture, Burma, has been granted leave on average pay for eight months from 10th March, 1926.

MR. D. RHIND, B.Sc., Mycologist, Burma, and Mr. W. M. Clarke, M.B.E., B.Sc., Professor of Agriculture, Agricultural College, Burma, have been confirmed in the Indian Agricultural Service from 21st March, 1926, and 3rd April, 1926, respectively.

CAPTAIN J. B. IDLE, M.R.C.V.S., Superintendent, Civil Veterinary Department, Central Circle, Burma, has been granted leave on average pay for eight months.

The Punjab Government is pleased to accept the resignation of MR. M. J. BRETT, M.R.C.V.S., of his appointment in the Indian Veterinary Service.

MR. W. M. CLARKE, M.B.E., B.Sc., Professor of Agriculture, Agricultural College, Mandalay, has been granted leave on average pay for six months from 15th April, 1926, Mr. J. W. Grant Officiating.

MR. D. HENDRY, M.C., N.D.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Burma, has been placed in charge of the Tenasserim Circle. in addition to his own duties, during the period Mr. J. W. Grant is on other duty.

MR. ARJAN SINGH, L. AG., 1st Assistant to the Imperial Agriculturist, has been appointed to hold charge of the current duties of Imperial Agriculturist, in addition to his own, from 15th March, 1926, *vice* Mr. G. S. Henderson on leave.

REVIEW

CROP PRODUCTION AND SOIL MANAGEMENT.—By Joseph F. Cox. Pp. XXX+516; figs. 222. (N w Yo:k : John Wiley and Sons; Lon'on : Chapman and Hall.) Price 13*s*. 6*d*. net.

This book, though written from an American point of view, contains a great deal of information that can be applied to Indian agriculture. It is written from the standpoint that crop production is the most important business of the nation, a fact which is doubly true in a country so overwhelmingly agricultural as India. The subject matter is a discussion of the methods developed by the most successful farmers in the United States and the contributions made by scientific research to modern crop production. The section on soil management is not so fully dealt with as the title of the book would justify, and is largely disposed of in the chapter dealing with the preparation of the seed-bed. A wide field is, however, covered under crop production, and useful and up-to-date information is given for both farmer and student. The selection and testing of seed and the control of weeds and crop pests are amongst the subjects best dealt with, and the information is such as can be universally applied. A feature of the book is its very detailed table of contents; to such an extent has this been developed that reference to the body of the book is rendered almost unnecessary. Another feature is the large and well chosen collection of photos and plates. The community studies at the end of each study are searching and should prove of much assistance to the thoughtful student. As a work on crop production, the book is a useful addition to the library. [H. R. S.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Sugar, by Geoffrey Fairrie. Pp. XIV+226. (Liverpool : Fairrie & Co., Ltd.) Price, 12*s*. 6*d*.
2. Planting Directory of Southern India, compiled by H. Waddington. Pp. vii+274. (London : John Bale, Sons and Danielsson, Ltd.; Coimbatore : The United Planters' Association of Southern India.) Price, 15*s*. net.
3. Soil Characteristics : A Field and Laboratory Guide, by Paul Emerson. Pp. X+222. (London : McGraw Hill Publishing Co.) Price, 12*s*. 6*d*. net.
4. Practical Fruit-Growing, by J. W. Morton. Pp. 192. (London : Ernest Benn, Ltd.) Price 10*s*. 6*d*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs

1. Studies in Gujarat Cotton, Part III. The Wagad Cotton of Upper Gujarat, Kathiawad and Kutch, by Maganlal L. Patel, M. Ag., and D. P. Mankad, (Botanical Series, Vol. XIV, No. 2.)
2. Drainage Waters at Cawnpore, by H. N. Batham, M.A., F.I.C.S. (Chemical Series, Vol. VIII, No. 8.) Price, As. 10 or 1*s*.
3. The Red Pumpkin Beetle (*Aulacophora abdominalis*, Fb.) and its Control ; with a short Note on *A. atripennis*, Fb., by M. Afzal Husain, M.Sc., M.A., and S. Abdullah Shah, L. Ag. (Entomological Series, Vol. IX, No. 4.) Price, R. 1 or 1*s*. 9*d*.

Bulletin

4. Standard Methods of Analysis of Fertilizers, edited by J. Sen, M.A., Ph.D., (Pusa Bulletin No. 164.) Price, As. 4 or 6*d*.

Reports

5. Review of Agricultural Operations in India, 1924-25. Price, Rs. 2-2 or 4*s*.
6. Proceedings of the Board of Agriculture in India, held at Pusa on 7th December, 1925, and following days (with appendices). Price, R. 1-14 or 3*s*. 3*d*.
7. Annual Report of the Institute of Veterinary Research, Muktesar, 1924-25.

List of Agricultural Publications in India from the 1st August 1925 to the 31st January 1926.

No	Title	Author	Where Published
	GENERAL AGRICULTURE		
1	The Agricultural Journal of India, Vol. XX, Parts V, VI and Vol. XXI, Part I. Price, Re. 1-8 or 2*s.* per part. Annual subscription Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Manager, Government of India Central Publication Branch, Calcutta.
2	Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau) for 1924-25. Price, Rs. 2-4 or 4*s.*	Issued from the Agricultural Research Institute, Pusa.	Ditto
3	Guide to the Agricultural Research Institute, Pusa.	Issued by the Director, Agricultural Research Institute, Pusa.	Ditto
4	Agricultural Statistics of India, 1922-23, Vol. I, Price, As. 12 or 1*s.* 4*d.*, Vol. II, Price As. 12 or 1*s.* 3*d.*	Issued by the Department of Commercial Intelligence and Statistics, India.	Ditto
5	Administration Report of the Indian Meteorological Department for the year 1924-25 and a History of the Department during the half-century 1875-1924.	Director-General of Observatories.	Simla Government of India Press.
6	Report on the Operations of the Department of Agriculture, Madras Presidency, for the official year 1924-25.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
7	Season and Crop Report of the Madras Presidency for the Agricultural year 1924-25 (*Fusli* 1334). Price, Rs. 2-8.	Ditto	
8	Villagers' Calendar, 1926 . .	Ditto	
9	Sugar varieties of the Bombay Presidency, India, Bombay Department of Agriculture Bulletin No. 122 of 1925.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press.

List of Agricultural Publications.

No	Title	Author	Where Published
	General Agriculture—contd.		
10	Ridge Cultivation in Lower Gujrat, Bombay Department of Agriculture Bulletin No. 123 of 1925.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press.
11	Season and Crop Report of the Bombay Presidency for 1924-25.	Ditto	Ditto
12	Report on the working of the Department of Agriculture, Central Provinces, for 1924-25.	F. J. Plymen, A. C. G. I., Director of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
13	Report on the Agricultural Stations in the Northern Circle, Central Provinces, for the year 1923-24. Price, Rs. 2.	J. H. Ritchie, M.A., B.Sc., Deputy Director of Agriculture, Northern Circle, Jubbulpore.	Ditto
14	Comments on the Return of Expenditure of the Provincial and District Gardens in the Central Provinces and Berar for the year ending the 31st March 1925.	Ditto	Ditto
5	Sugarcane Cultivation. Central Provinces Department of Agriculture Bulletin No. 21.	G. K. Kelkar, B.Ag., Extra Assistant Director of Agriculture.	Ditto
16	Season and Crop Report of the Central Provinces and Berar for the year 1924-25. Price, Rs. 3-8.	Issued by the Department of Land Records, Central Provinces.	Ditto
17	Annual Report of the Department of Agriculture, Bihar and Orissa for 1925.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Gulzarbagh.
18	Agricultural Statistics of Bihar and Orissa for 1924-25.	Ditto	Ditto
19	Improved Cattle for Bengal. Bengal Department of Agriculture Leaflet Nos. 6 and 7 (in English and in Bengali).	Issued by the Department of Agriculture, Bengal.	Bengal Government Press, Calcutta.
20	Annual Report on the Administration of the Department of Agriculture, United Provinces, for the year ending 30th June 1925.	Issued by the Department of Agriculture, United Provinces.	Superintendent of Government Press, Allahabad.
21	Report on the Agricultural Stations of Central Circle, Cawnpore, United Provinces, for the year 1924-25.	Ditto	Ditto

List of Agricultural Publications—*contd.*

No	Title	Author	Where Published
	General Agriculture—contd.		
22	Report on the Agricultural Stations of Western Circle, United Provinces of Agra and Oudh for the year ending 31st May 1925.	Issued by the Department of Agriculture, United Provinces.	Superintendent of Government Press, Allahabad.
23	Combined Report on the Experimental Stations in the Eastern Circle, Partabgarh for the year ending 31st May 1925.	Ditto	Ditto
24	Report on Agricultural Stations of the North-eastern Circle. United Provinces, for the year 1924-25.	Ditto	Ditto
25	Report on the Agricultural Stations in the Rohilkhand Circle, Shahjahanpur, United Provinces, for the year ending 31st May, 1925.	Ditto	Ditto
26	Report on the working and Administration of United Provinces Government Gardens for the year 1924-25.	Ditto	Ditto
27	Sheep-Breeding Experiments in the United Provinces by the Civil Veterinary Department during the years 1912 to 1923.	Captain S. G. M. Hickey, M.R.C.V.S., I.V.S., Veterinary Adviser to Government, United Provinces.	Ditto
28	Season and Crop Report of the United Provinces of Agra and Oudh for the year 1924-25. Price, As. 14.	Issued by the Department of Land Records, United Provinces of Agra and Oudh.	Ditto
29	Annual Report on the Operations of the Department of Agriculture, Punjab, for the year ending 30th June 1924, Part II, Vols. I and II (Annual Record of Experimental work). Price, Rs. 11.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
30	Seasonal Note for October 1925. Price, Rs. 3.	Ditto	Ditto
31	Report on the Lawrence Gardens for the year 1924-25 Price, As. 8.	Ditto	Ditto

List of Agricultural Publications—*contd.*

No	Title	Author	Where Published
	General Agriculture—contd.		
32	Season and Crops of the Punjab for the year 1924-25. Price, Rs. 3 or 4*s*.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
33	Tables of Agricultural Statistics for 1924-25 of the Punjab Department of Agriculture.	Ditto	Ditto
34	List of dates of horse and Cattle Fairs for 1925-26.	Ditto	Ditto
35	Results of Trials of Chattonooga No. 44 Power Crusher at Gurdaspur. Punjab Department of Agriculture, Leaflet No. 33.	Ditto	Ditto
36	Some hint on Potato Cultivation in the Punjab Plains. Punjab Department of Agriculture Leaflet No. 35.	Ditto	Ditto
37	Broom-rape and its eradication. Punjab Department of Agriculture, Leaflet No. 38.	Ditto	Ditto
38	Report on the Season and Crops of the North-West Frontier Province for the year 1924-25. Price, Re. 1-7 or 2*s*. 5*d*.	Revenue Commissioner, North-West Frontier Province.	North-West Frontier Province Government Printing and Stationery office.
39	Report of the Agricultural Department, Assam, for the year ending 31st March, 1925.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
40	Tables of the Agricultural Statistics of Assam for the year 1924-25.	Ditto	Ditto
41	Report on the Operations of the Department of Agriculture, Burma, for the year ended 30th June, 1925.	Issued by the Department of Agriculture, Burma.	Goverment Printing and Stationery, Burma, Rangoon.
42	Report on the Mandalay Agricultural Station for the year ended 30th June 1925.	Ditto	Ditto
43	Report on the Padu Agricultural Station for the year ended 30th June 1925	Ditto	Ditto
44	Report on the Tatkon Agricultural Station for the year ended 30th June 1925.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No	Title	Author	Where Published
	General Agriculture—contd.		
45	Report on the Yawnghwe Agricultural Station for the year ended 30th June 1925.	Issued by the Department of Agriculture, Burma.	Government Printing and Stationery, Burma. Rangoon.
46	Report on the Mahlaing Agricultural Station for the year ended 30th June 1925.	Ditto	Ditto
47	Report on the Allanmyo and Pwinbyu Seed Farm for the year ended 30th June 1925.	Ditto	Ditto
48	Report on the Akyab Agricultural Station for the year ended 30th June 1925.	Ditto	Ditto
49	Report on the Hmabi Agricultural Station for the year ended 30th June 1925.	Ditto	Ditto
50	Annual Report of the Agricultural Engineer, Burma.	Ditto	Ditto
51	Agricultural Statistics of Burma for the year 1924-25. Price, Re. 1-8 or 2*s.* 3*d.*	Published by Commissioner of Settlements and Land Records, Burma.	Ditto
52	Season and Crop Report of Burma for the year ending the 30th June 1925. Price, Re. 1 or 1*s.* 6*d.*	Ditto	Ditto
53	Mysore Agricultural Calendar, 1926.	Department of Agriculture, Mysore.	Government Press, Bangalore.
54	*Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual subscription, Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
55	The Journal of the Indian Botanical Society. (Formerly the Journal of Indian Botany.)	Edited by P. F. Fyson, M. A., F.L.S.	The Methodist Publishing House, Madras.
56	*The Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription, Rs. 4. Single copy, As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
57	*The Planters' Chronicle* (Weekly).	United Planters' Association of South India, Coimbatore.	Electric Printing Work, Coimbatore.

List of Agricultural Publications—*contd.*

No	Title	Author	Where Published
	General Agriculture—concld.		
58	*Poona Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 2, Single copy, As. 10.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
59	*The Old Boys' Magazine, Agricultural College, Cawnpore* (Quarterly). Price, As. 8 per copy, Annual subscription, Rs. 2.	M. L. Saksena, L. Ag., Editor.	Cawnpore Printing Press.
60	*The Allahabad Farmer* (Quarterly). Single copy, As. 8; per year Rs. 2.	W. B. Hayes, A. Sinha, N. R. Joshi. } Editors.	The Mission Press, Allahabad.
61	*The Bengal Agricultural Journal* (Quarterly). (In English and Bengali). Annual subscription, Re. 1-4, Sinlge copy As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
62	*Quarterly Journal of the Indian Tea Association.* Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
63	*Indian Scientific Agriculturist.* (Monthly). Annual subscription, Rs. 4.	H. C. Sturgess, Editor, J. W. McKay, A.R.C.Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Co. 52-53, Bowbazar Street, Calcutta.
64	*Rural Bengal.*	N. N. Gupta, B.A., Ph.D., B.Sc., Editor.	Sremat Bhagabat Press: Bhowanipore, Calcutta.
65	*Krishak* (Bengali). (Monthly.) Price, As. 5 per copy. Annual subscription, Rs. 3-3.	U. C. Banerjee, Editor.	Sri Ram Press, 162, Bowbazar Street, Calcutta.
	AGRICULTURAL CHEMISTRY		
66	The Quality and yield of Tobacco as influenced by Manurial and other Operations. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 1. Price, As. 8 or 9*d.*	J. N. Mukherji, B.A., B.Sc.	Manager, Government of India Central Publication Branch, Calcutta.
67	Investigations on Indian Opium, No. 4—Further Experiments on the Influence of Manures on the Yield and Morphine content of the latex of the opium poppy.	Harold E. Annet, D.Sc., F.I.C., M.S.E.A.C., and Har Dayal Singh, B.Sc.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where Published.
	***Agricultural Chemistry*—contd.**		
	No. 5—Experiments on oil content of the seed of the opium Poppy; and No. 6—Studies on the Ash constituents of Indian Opium. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, Nos. 2-4. Price, As. 8 or 10*d*.	Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., and M. N. Bose, M.A.	Manager, Government of India Central Publication Branch, Calcutta.
68	Nitrogen Recuperation in the Soils of the Bombay Deccan. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 5. Price, As. 4 or 5*d*.	D. L. Sahasrabuddhe, M.Ag., M.Sc., and J. A. Daji, B.Ag., B.Sc.	Ditto
69	Deterioration of Sugarcane during its storage by Windrowing. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 7. Price, As. 6 or 8*d*.	Phani Bhusan Sanyal, M.Sc.	Ditto
70	Annual Report of the Agricultural Chemist, Burma, for the year ended 30th June 1925.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
	BOTANY		
71	A Study of some Indian Grasses and Grasslands. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIV, No. 1. Price, As. 12 or 1*s*. 3*d*.	W. Burns, D.Sc., L. B. Kulkarni, M.Ag., and S. R. Godbole, B.Ag., B.Sc.	Manager, Government of India Central Publication Branch, Calcutta.
72	Report of the Botanical Survey of India for 1924-25.	C. C. Calder, Director, Botanical Survey of India.	Manager, Government of India Press, Calcutta.
73	Annual Report of the Economic Botanist, Burma, for the year ended 30th June 1925.	Issued by the Department of Agriculture, Burma.	Government Printing and Stationery Burma, Rangoon.
	MYCOLOGY		
74	Bordeaux or Burgundy mixture as a preventive to Potato disease (*Phytophthora*) (in English).	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
75	Annual Report of the Mycologist, Burma, for the year ended 30th June 1925.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where Published.
	ENTOMOLOGY		
76	A Contribution towards a Monograph of the Indian Coniopterygidæ (Neuroptera).	C. L. Withycombe, Ph.D., M.Sc., D.I.C.	Manager, Government of India Central Publication Branch, Calcutta.
	The Bionomics and Lifehistories of some of the Common Tabanidæ of Pusa ; and some Observations on the Life history and Habits of *Phycus brunneus*, Wied (Family Therevidæ). Memoirs of the Department of Agriculture in India. Entomological Series, Vol. IX, Nos. 1-3. Price, Rs. 2-2 or 4*s*.	P. V. Isaac, B.A., M.Sc., D.I.C., F.E.S.	Ditto
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78	The Rice Hispa—A pest of paddy. Madras Department of Agriculture Leaflet No. 1 (revised) (in English, Tamil, Kanarese and Malayalam).	Rao Sahib Y. Ramachandra Rao, Government Entomologist, Coimbatore.	Government Press, Madras.
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80	Annual Report of the Entomologist and Sericultural Work, Burma, for the year ended 30th June 1925.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
81	A Note on Kutra (Hairy Caterpillars of Amsecta species). Punjab Department of Agriculture Leaflet No. 36.	Issued by the Department of Agriculture, Punjab.	Government Printing Punjab, Lahore.
82	Attack of Sugarcane Borers and how to reduce them. Punjab Department of Agriculture Leaflet No. 37.	Ditto	Ditto
83	Lantana known as *Pang Phuli*. Punjab Department of Agriculture Leaflet No. 39.	Ditto	Ditto

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No.	Title.	Author.	Where Published.
	BACTERIOLOGY		
84	Loss of Sugar by inversion in Sugar Factories in Northern India and its prevention by Antiseptic Measures. Pusa Agricultural Research Institute Bulletin No. 163. Price, As. 2 or 3*d*.	C. M. Hutchinson, C.I.E., B.A., and C. S. Ram Ayyar, B.A.	Manager, Government of India Central Publication Branch, Calcutta.
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85	Nasal Granuloma in Cattle. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. III, No. 6. Price, Re. 1 or 1*s*. 6*d*.	V. Krishnamurti Ayyar, I.V.S.	Manager, Government of India Central Publication Branch, Calcutta.
86	Skin Diseases of Dogs. Punjab Department of Agriculture Bulletin No. 15 (in Urdu).	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
87	A Further note on Surra Transmission experiments with Ticks. Punjab Department of Agriculture Bulletin No. 8.	Ditto	Ditto
88	Annual Administrative Reports of the Bombay Veterinary College, Glanders and Farcy Department and Civil Veterinary Department in the Bombay Presidency (including Sind) for the year 1924-25.	Issued by the Civil Veterinary Department, Bombay.	Government Central Press, Bombay.
89	Annual Report of the Bengal Veterinary College and Civil Veterinary Department, Bengal, 1924-25. Price, Re. 1 or 1*s*. 9*d*.	Issued by the Civil Veterinary Department, Bengal.	Bengal Government Press, Calcutta.
90	Annual Report of the Civil Veterinary Department, Bihar and Orissa, for the year 1924-25. Price, Re. 1-4.	Issued by the Civil Veterinary Department, Bihar and Orissa.	Government Printing, Bihar and Orissa, Patna.
91	Annual Report of the Civil Veterinary Department, United Provinces, for the year ending 31st March 1925. Price, Re. 1-8.	Issued by the Civil Veterinary Department, United Provinces.	Government Press, United Provinces, Allahabad.
92	Report of the Civil Veterinary Department of the Central Provinces and Berar for the year 1924-25. Price, Re. 1.	Issued by the Civil Veterinary Department, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.

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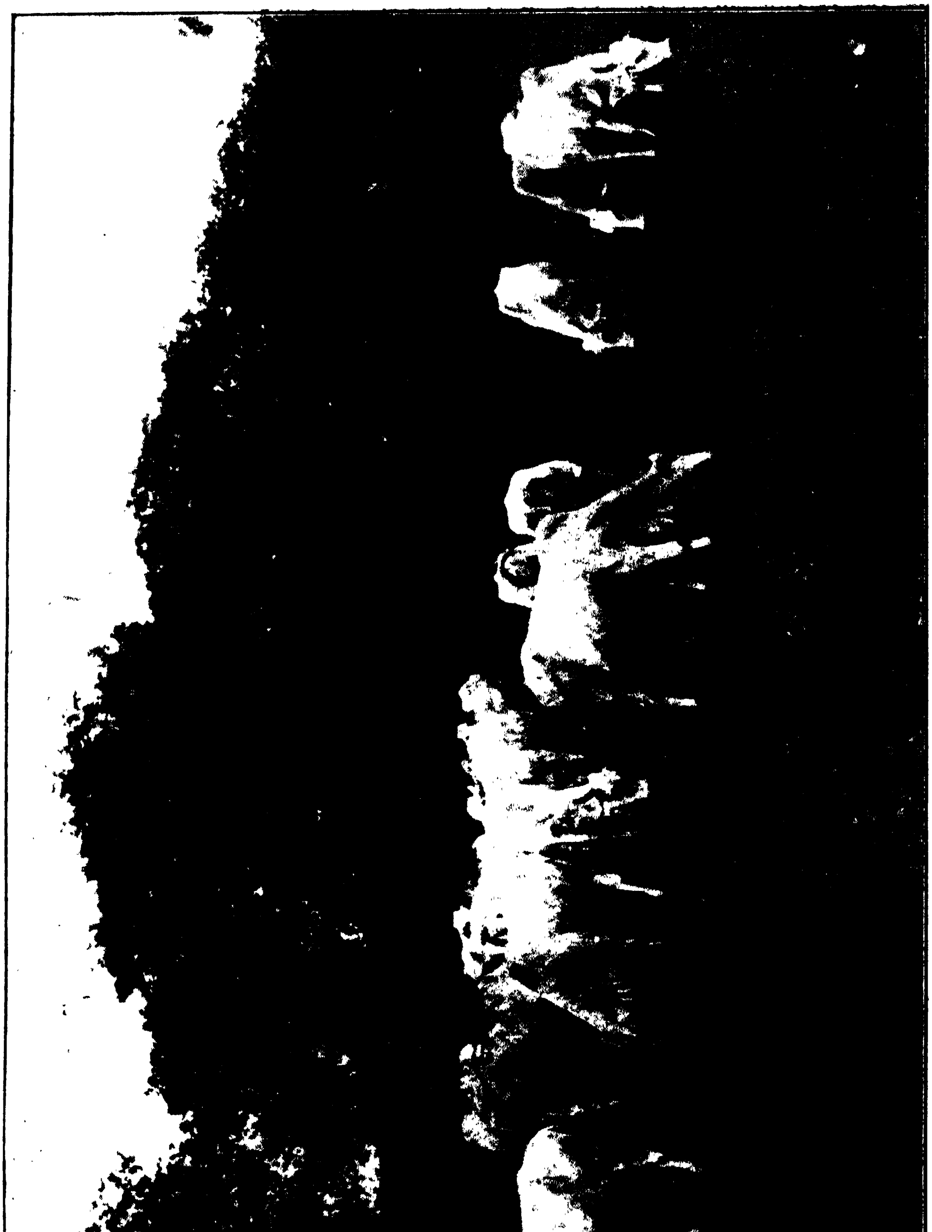
No.	Title.	Author.	Where Published.
	Veterinary—contd.		
93	Report of the Civil Veterinary Department (including the Insein Veterinary School), Burma, for the year ending 31st March 1924. Price, Re. 1 or 1*s*. 6*d*.	Issued by the Civil Veterinary Department, Burma.	Government Printing, Burma, Rangoon.
94	Report of the Civil Veterinary Department, Assam, for the year 1923-24. Price, As. 8 or 9*d*.	Issued by the Civil Veterinary Department, Assam.	Assam Secretariat Printing Office, Shillong
95	Report of the Civil Veterinary Department, North-West Frontier Province, for the year 1924-25. Price, As. 15 or 1*s*. 1*d*.	Issued by the Civil Veterinary Department, North-West Frontier Province.	North-West Frontier Province Government Press.
96	Annual Report on the working of the Government Stud Farm, Kunigal for 1924-25 with the Government Review thereon.	Issued by the Department of Agriculture, Mysore.	Government Press, Bangalore.

PLATE VIII.



IN PASTURES GREEN. ONE OF THE ONGOLE HERDS OF THE MADRAS DEPARTMENT OF AGRICULTURE AT HOSUR.

ORIGINAL ARTICLES

BREEDS OF INDIAN CATTLE.

II. THE ONGOLE OR NELLORE BREED.

BY

W. SMITH,

Imperial Dairy Expert;

AND

R. W. LITTLEWOOD, N.D.A.,

Deputy Director of Agriculture, Live Stock, Madras.

Both of the above names have been freely used in the past in describing this well known and valuable breed of Indian cattle, but the use of this nomenclature does not mean that the breeding of these animals is confined to either the Ongole or Nellore Districts, as they are bred in all parts of the district lying between the river Manneru in the Nellore District and the river Krishna in the Guntur District—a distance of say 100 miles along the coast line and varying from 50 to 60 miles inland from the sea. The famous Krishna Valley cattle from the Belgaum District of the Presidency of Bombay are also of this breed or type, although they have in the course of years been bred in this very fertile district of a larger size than the Nellore cattle of the Madras Presidency. Both in the Bombay Presidency and in the breeding grounds in Northern Madras, the cattle are mostly bred on the banks of streams and rivers. The breeding tract in the Madras Presidency is a dry one, the rainfall on the whole being under 30 inches with frequent failures from year to year.

The breed is said to have been founded in the days of the Andhra kings long before the advent of the Mohammadans by the importation of cattle from Northern India.

From the commencement of British rule in this country notice has been taken of the fine cattle found in the Nellore District, and in the meagre literature available concerning Indian dairying this breed is always referred to. In "Dairy Farming in India" by Meagher and Vaughan published in 1904, a very good photo of a Nellore cow is reproduced and the breed is referred to as fairly good milkers.

In the volume "Cattle of Southern India" written by Col. W. D. Gunn, Superintendent of the Madras Veterinary Department, and published by the Government of Madras in 1909, no less than 19 photographs are reproduced illustrative of this breed, and a fairly elaborate account is given of the habitat of the breed, its characteristics, and the system of breeding, rearing and marketing in vogue in the breeding tracts. No information is given as to results of recorded milk yields, quality of the milk yielded, frequency of calving, etc.

In colour the Ongole breed are generally a light grey to pure white with black points, but animals are frequently found red and white in colour (Plate X). The coat is fine and silky to the touch, the skin slack, smooth and not too fine.

The very best class of bulls weigh as much as 1,800 lb., good average cows weigh between 800 and 900 lb., and first class working bullocks under common working conditions run about 1,200 to 1,300 lb. weight.

The principal physical features of the breed may be classed as follows :—

Head. Face moderately long. Muzzle fine, forehead broad. Eyes elliptical in shape, large and mild. Skin around the eyes for about half an inch is black. Ears long and drooping. Horns generally short and of various shapes. In cows the horns are a little longer, thin and turn outwards and slightly backwards. The shape and size of the horns vary in different parts of the tract and also with the age of the animal. Ears long and drooping.

Neck. Short and thick.

Hump. Well developed. In the older males to such an extent that it droops over to one side.

Body. Massive, long and deep. Big girth measurement. In fine specimens the girth behind the hump is about 84 inches and the height behind the hump 63 inches.

Back. Of moderate length and inclined to be higher at the croup.

Quarters. Strong with a considerable droop.

Dewlap. Loose, pendulous, thick and sometimes folded. Extends as far as sheath.

Sheath. Pendulous. Cows also have a fold of the skin in the position of the sheath.

Tail. Long, fine, and tapering with a good tuft of black hair at the end. The tail extends below the hocks.

Legs. Strong and with good bone.

Feet. Large and soft looking, narrow cleft between the hoofs.

The Ongole breed are docile, easily trained for any class of work, and many working animals are handled without nose rope. When compared with the swift Amrit Mahal or the agile Kangayam breeds of Southern India, they are moderately slow walkers but very powerful and possessing great spirit and powers of

Fig. 1. Ongole cow showing typical body formation and shape of horns.

Photo lent by Mr. F. Ware, F.R.C.V.S.

Fig. 2. Champion pair of bullocks, Ongole Show, 1915.

PLATE X.

Fig. 1. Champion bull (4 teeth), Ongole Show, 1915.

Photos lent by Mr. F. Ware, F.R.C.V.S.

Fig. 2. Champion bull (8 teeth), Ongole Show, 1915.

endurance. They are the ideal working cattle for the heavy soils of the Northern Circars. In fact, as a powerful and efficient working bullock of the heavier type, the Ongole breed is probably equal to the best breeds of the Bombay Presidency, Central and Northern India. In days gone by, this breed had a great reputation as milch cattle and they still are easily the best milking breed of Southern India.

The late Deputy Director of Agriculture, Live Stock, Madras, has left on record that some 3,000 cows and heifers of this breed are sent from the Ongole District annually to Madras city to meet the demand for fresh milk there. Some of these after they go dry in Madras are sent back to the breeding tracts until they calve again. In fact the Ongole breed is to-day a standing proof of the utility of the dual purpose cow for this country. Up to the present very few authentic records of the milk yield of Ongole cows have been kept, but the following accurate figures will convey some idea of the milking qualities of the breed.

Milk yields with analysis of 6 individual cows in the herd of the Madras Agricultural Department.

No. of days in milk	Yield during lactation	Average yield per day	No. of days dry	Date of calving	Milk Analysis: Date	Morning: Milk yield	Morning: Butter fat	Evening: Milk yield	Evening: Butter fat
	lb.	lb.				lb.	Per cent.	lb.	Per cent.
Cow No. 3 Parwathi; Weight 796 lb.; Colour white; Born 1918.									
157	313·1	3·07	472	..	15-9-25	3·0	4·9	2·5	5·2
					16-9-25	3·0	4·8	5·0	6·0
336	3421	10·3	124	..	17-9-25	3·8	5·2	3·0	5·4
					18-9-25	3·0	5·1	3·0	6·6
245	4030	16·4	195	..	19-9-25	3·0	5·0	4·0	5·4
					20-9-25	3·5	4·9	3·0	6·4
100*	1578	14·5	..	30-5-25	21-9-25	3·0	4·7	3·0	5·7
					Average	3·2	4·9	3·1	5·8
Cow No. 5 Satyabhama; Weight 868 lb.; Colour white; Born 1918.									
207	2283·8	11·0	380	..	15-9-25	7·0	4·6	6·5	4·1
					16-9-25	6·5	4·0	7·0	5·5
					17-9-25	6·5	4·3	6·0	4·4
341	2856·8	8·6	251	..	18-9-25	7·0	4·5	7·0	5·0
					10-9-25	6·5	4·6	6·0	5·8
					20-9-25	7·0	4·2	7·0	5·3
38*	428	11·3	..	9-8-25	21-9-25	7·0	4·4	6·0	4·9
					Average	6·8	4·4	6·5	5·0

* Current.

Milk yields with analysis of 6 individual cows in the herd of the Madras Agricultural Department—contd.

No. of days in milk	Yield during lactation	Average yield per day	No. of days dry	Date of calving	MILK ANALYSIS				
					Date	MORNING		EVENING	
						Milk yield	Butter fat	Milk yield	Butter fat
	lb.	lb.				lb.	Per cent.	lb.	Per cent.
Cow No. 6 Janaki; Weight 868 lb; Colour white; Born 1918.									
247	2356·8	9·6	296	..	15-9-25	4·0	4·9	3·8	5·4
					16-9-25	4·5	5·5	4·0	5·6
18	1201	11·2	386	..	17-9-25	4·5	4·8	3·8	5·1
					18-9-25	4·0	4·8	3·8	5·7
315	2997·8	9·5	165	..	19-9-25	3·5	4·6	4·8	5·3
					20-9-25	4·5	5·1	3·5	4·8
202*	1901	9·4	..	25-2-25	21-9-25	4·0	5·0	3·5	5·2
					Average	4·1	4·9	3·9	5·3
Cow No. 18 Radha; Weight 772 lb.; Colour white; Born 1916									
358	1353·2	9·0	109	..	15-9-25	9·9	4·8	7·0	5·6
					16-9-25	8·0	5·0	7·5	5·4
255	2481·9	9·7	120	..	17-9-25	8·0	4·4	7·0	4·9
					18-9-25	8·5	4·7	7·0	5·0
354	4723	13·3	133	..	19-9-25	7·0	4·8	5·8	5·2
					20-9-25	7·3	4·4	7·0	4·8
213	[illegible]037	14·3	82	..	21-9-25	7·0	5·0	6·5	5·7
114*	1887	16·6	..	24-5-25	Average	7·8	4·7	6·5	5·2
Cow No. 21 Mahalakshmi; Weight 859 lb.; Colour white; Born 1917.									
250	2310·8	9·2	170	..	15-9-25	6·0	5·1	5·5	5·3
					16-9-25	5·0	4·8	5·5	6·1
404	3498	8·7	166	..	17-9-25	5·5	4·5	5·0	6·2
					18-9-25	5·0	4·4	5·0	5·6
222	3670	16·5	92	..	19-9-25	4·5	4·7	4·0	5·2
					20-9-25	5·5	5·2	5·0	5·3
133*	1891	14·2	..	6-5-25	21-9-25	5·0	4·5	5·0	6·0
					Average	5·2	4·7	5·0	5·8

* Current.

Milk yields with analysis of 6 individual cows in the herd of the Madras Agricultural Department— concld.

No. of days in milk	Yield during lactation	Average yield per day	No. of days dry	Date of calving	MILK ANALYSIS				
					Date	Morning		Evening	
						Milk yield	Butter fat	Milk yield	Butter fat
	lb.	lb.				lb.	Per cent.	lb.	Per cent.
Cow No. 44 Ratnathai ; Weight 804 lb. ; Colour white ; Born 1914.									
119	640·5	5·4	258	..	15-9-25	5·0	5·1	4·5	4·9
					16-9-25	4·5	4·6	4·0	5·6
392	3233·5	8·2	177	..	17-9-25	5·0	5·4	4·5	4·5
					18-9-25	5·0	4·9	4·0	5·1
271	2810·9	10·6	159	..	19-9-25	4·5	5·7	4·0	5·2
					20-9-25	4·3	4·8	3·5	4·8
207*	2495·0	12·1	.	20-2-25	21-9-25	4·0	4·9	3·8	5·9
					Average	4·6	5·1	4·0	5·1

* Current.

List of Ongole cows at Agricultural College Dairy, Coimbatore, with yields and average fat percentage.

Serial No.	Name and number of cow	Milk yields in lb.	Average % of fat
1	Rajah 19	3529¼, 4972, 5012, 4624	4·8
2	Balamani 3/3	3002, 2362½, 3050, 3668	4·3
3	Meenaksni 4/4	1295, 1253, 1474, 819	4·9
4	Rangi 20/20	2347, 2736, 2163	4·3
5	Parwathi 21/21	2484, 2106, 1611	3·8
6	Thulasi 22/22	2239, 2581, 2810	3·4
7	Lilawathi 24/15	2605, 1260, 1861½	5·4
8	Kalyani 52/40	2305, 1205	4·6
9	Amrawathi 64/58	1821, 1802	5·1
10	Padma 46/43	2972, 1953½	3·8
11	Lakshmibai 5/5	3719·6	..
12	Thulia 53/50	530	5·2
13	Thangam 114/88	2857, 605	..
14	Kaikei 106/36	2690, 2742, 2452, 17 9¾	..
15	Naga 57	351¾	..

Milk yields of Ongole cows at ***Hosur Farm.***

No. of cow	1st Lactation				2nd Lactation				3rd Lactation				4th Lactation				
	Milk yield	Days in milk	Daily average	Days dry	Milk yield	Days in milk	Daily average	Days dry	Milk yield	Days in milk	Daily average	Days dry	Milk yield	Days in milk	Daily average	Days dry	
	lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		
1	2,994	189	15·8	389	3,433	380	9·1	179	2,351	199	11·8	206	..	..	..	..	
2	313	157	2·0	472	3,421	336	10·2	124	4,030	245	16·4	195	1,368	94	14·6	..	Now in milk.
4	3,567	279	12·8	248	3,101	264	11·8	..	..	..	..	..	..	..	..	..	
5	2,283	207	11·0	380	2,856	341	8·4	251	263	23	11·5	..	..	..	..	..	Now in milk.
6	2,356	247	9·5	296	201	18	11·2	386	2,997	315	9·5	165	1,766	187	9·5	..	Do.
13	1,353	358	3·8	109	2,481	255	9·7	120	4,723	354	13·3	133	1,647	99	16·6	..	Do.
16	1,660	346	4·8	232	2,936	398	7·4	163	3,266	348	9·4	154	..	..	..	..	
21	2,310	250	9·2	170	3,498	404	8·7	166	3,670	222	16·5	92	1,681	118	14·2	..	Now in milk.
25	3,144	333	9·4	223	3,906	294	13·3	202	3,952	335	11·2	..	..	..	..	..	
30	2,653	304	8·7	120	3,827	362	10·6	190	3,625	309	11·7	88	..	..	..	..	
32	3,972	332	12·0	204	2,662	210	12·7	157	1,385	94	14·7	..	..	..	..	..	
33	819	262	3·1	52	4,022	361	11·2	..	..	..	..	..	..	..	..	..	
35	1,302	351	3·7	411	2,919	302	9·7	155	2,914	294	10·0	142	599	70	8·6	..	
44	640	119	5·4	258	3,233	392	8·2	177	2,810	271	10·6	159	2,315	192	12·0	..	Now in milk.
48	3,342	440	7·6	253	2,720	296	9·4	..	..	..	..	..	..	..	..	..	
54	3,302	436	7·6	..	..	..	..	..	..	..	..	..	..	..	..	..	
59	2,167	271	8·0	..	..	..	..	..	..	..	..	..	..	..	..	..	

Fig. 1. Ongole cow No. 32, Hosur Farm. Gave 3,972 lb. of milk in 332 days.

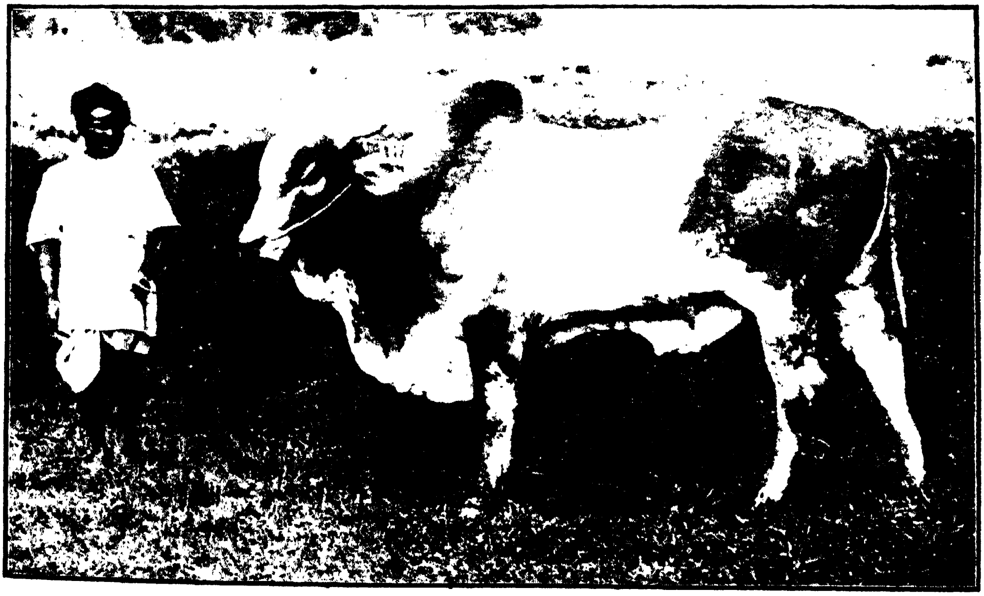


Fig. 2. Ongole stud bull, Hosur Farm.

Fig. 1. Brazilian bred Ongole bull "Tango"; 3½ years old; weight 1,800 lb.

Fig. 2. Brazilian bred Ongole heifer "India"; 3 years old.
(Both property of Gino de Bellens Bezzi, Barra Mansa Estate, Rio de Janeiro.)

The Ongole breeders from time immemorial appear to have paid great attention to the selection of the bull for breeding purposes, and even to-day when the Brahmani system of relying on dedicated bulls has largely fallen into disuse considerable care is taken on the mating of the cattle, and consequently the breed is from an Indian point of view a comparatively pure one and can generally be depended on to breed true to type, a fact which is borne out by a study of the half European milch cattle of Madras, many of which show clear indications of their Nellore blood. The foregoing figures show that the cows of this breed rank amongst the first class of Indian milch cows, and it is certain that if scientific breeding by selection along milk producing lines were practised a vast improvement could be made in the milking qualities of the breed. Breeding in times past has been largely done by Brahmani bulls or other male stock selected entirely on their appearance and without any regard whatever to the milking qualities of the female stock from which bulls were got, and in view of this it is remarkable that so many good milkers of the breed are still available.

Carefully reared bullocks of the breed are ready for work when about 4 years of age, and heifers generally take the bull at about 3 years and calve before they are 4 years of age.

The foregoing figures will show that the dry period in milking cows is generally of longer duration than it ought to be, but in this respect the Ongole is better than most of the heavier breeds of Northern India, and in well managed herds there should be no difficulty in getting cows to calve on the average once in 15 to 16 months. The breed is hardy and carries a high degree of resistance to the common diseases of the country.

There is probably no breed of oriental cattle so well known outside of their own country as the Ongole breed. Large numbers of both sexes of these animals have been in the past exported to Brazil and the other South American Republics, West Indies, Cuba, Mexico, Southern States of America, Java, Straits Settlements, Ceylon, Sumatra, Borneo, Siam. Formosa, Hong-Kong and Southern China. In fact, so highly did the foreign tropical buyers esteem the dual purpose qualities of this breed that very high prices were paid for the best classes of animals, and consequently the breeding districts were being depleted of not only the young bulls but the best of the female stock were being exported. To prevent the extinction of the breed, the Madras Government some years ago passed a law prohibiting the export of cattle of this breed from the Madras Presidency which law is still in force.

Very fine pedigree herds of the breed have been founded in Sumatra, West Indies, Cuba and Brazil, and the animals are bred pure in these countries where they have a very high reputation not only for their draught and milking qualities but as sires for crossing with local and European breeds of cattle for the production of beef. Plate XII is of pure bred Nellore animals bred and reared in Brazil.

The Agricultural Department of the Government of Madras has founded pure herds of Ongole cattle at Chintaladevi in the northern part of the presidency and at

Hosur in the Salem District. Accurate milk records are maintained at these stations, and breeding on dual purpose lines carefully practised.

Young bulls of the proper stamp are reared for distribution in the breeding districts, and it is hoped that when the breeders can be organized to breed and rear these cattle on scientific lines the prohibition on export of heifers may be removed, thus again opening the lucrative foreign market without the danger of extinguishing the breed.

SCOPE OF A MODERN AGRICULTURAL DEPARTMENT

PRESIDENTIAL ADDRESS AT THE AGRICULTURAL SECTION OF THE INDIAN SCIENCE CONGRESS, 1926.

BY

G. S. HENDERSON, N.D.A., N.D.D.,

Imperial Agriculturist, Pusa.

I HAVE much pleasure in welcoming the delegates to this meeting and trust that the present session will result not only in the digestion of the very valuable papers which have been contributed but also in fruitful discussions on the points at issue. The present time is one of great importance to agricultural interests in India. More prominence is being given to the study of agricultural conditions and problems in India by Government than at any time in the past: it is recognizing that agriculture is our fundamental industry. Lord Reading said in a recent speech: "As I grow older in my service to India, as I learn to understand her (India's) problems, as I perceive more keenly the anxieties of India, I come more and more to the conclusion, aided and assisted by those who have the knowledge and experience, that the great industry of India, to which India must look for her regeneration and her prosperity, is her agriculture; and we must do all we can to further it." This will certainly mean the strengthening of the Provincial Agricultural and Co-operative Departments. Under the Reforms Scheme, agriculture is now a transferred subject and the Provincial Departments of Agriculture are entirely under the jurisdiction of the local Provincial Councils. Whether this change will prove in the long run successful, I would not venture to forecast. It was in any case a somewhat drastic step to take with young departments, and this departure will certainly entail some difficulty in organizing and strengthening the hands of a central co-ordinating body.

My predecessor, in his presidential address of last year, dealt with some aspects of the work of a Provincial Department of Agriculture. He particularly laid stress on the results obtained by the plant breeder in raising the standard of crop production. It is obviously a fact that district research and propaganda is the fundamental work of the Agricultural Department. This combined with cattle-breeding and the study of farm machinery, implements, well-boring, principles of rotation, upkeep of fertility, manures and manuring are the aspects most prominent to the average observer. Very much more than this, however, is represented or should be represented in the activities of an Agricultural Department. I wish to put briefly

before you the possible scope of a modern Agricultural Department in order to obtain the benefit of your views on this very important subject at a somewhat critical moment in the history of the agricultural movement in India.

In considering this subject, it is necessary to use with care the term "Indian Agriculture." There is really no such thing, and people are apt to imagine a homogeneous whole when such a thing does not exist. Agricultural conditions vary more in different tracts of India than between Finland and the South of Spain. There are large areas of famine stricken land and areas of marvellously rich land giving three rice crops annually in the alluvial deltas of the South, and contrasts like the rich paddy land of Bengal and the arid wastes of Rajputana. Districts there are where the price of agricultural land may be a thousand rupees an acre, and others where land may be got for a few rupees. There are districts where money is plentiful, where the most modern agricultural machinery can be found and where any practical and proved agricultural improvement is likely to meet with a ready welcome, while there are others where agriculture is still in the most primitive state.

I should like to deal at the beginning with some of the common criticisms of the work of Agricultural Departments in India. The most general one is that the experiment stations are too elaborate, the buildings much too expensive and the whole system unlikely to do any good, as these farms cannot be copied by the average ryot. These stations are in most cases for research purposes; they are field laboratories and, as such, are not meant to be copied by the ryot. Their duty is to get results and these results have to be translated into practical agriculture, probably one or two simple recommendations at a time which by means of the district propaganda staff are in turn demonstrated in the villages. The buildings, too, are not the affair of the Agricultural Department. They are type designs built by the Public Works Department in accordance with Government rules; in most cases the Agricultural Department has no power to modify them. The staff also has got to conform to Government rules, and the whole establishment becomes much more expensive than a similar concern run by private enterprise

Another criticism is that the ryot still keeps to his traditional methods and seems to be unaffected by the presence of improved methods in his district. This, to a certain extent, is undoubtedly true. But the reasons are obvious. First, it is merely a matter of proportion. A few experiment stations can have only a very slow effect on the vast area of even a single district. The means must bear some proportion to the end required. There are more than 225,000,000 acres cultivated in British India, so a hundred farms or so are quite inadequate to leaven such a large mass. Secondly, a considerable proportion of the agricultural population of India is on the border line of extreme poverty; a good monsoon puts them slightly above this line and a deficient rainfall sends them right below the line. In many cases they are bound by the cast-iron fetters of their economic environment such as fragmentation of holdings, debt, diseases of man and cattle, etc., so that better

farming is in their case an impossibility until their general economic state is ameliorated. "Hasten slowly" is an invaluable motto in these circumstances. The ryot, especially in tracts liable to periodic failure of rain, has established a nice equilibrium between his available manure and his crop output. His traditional methods have the experience of years behind them and are not lightly to be disturbed without the greatest care and possibly in the first place by the alteration of his economic circumstances. Irrigated areas are the bright spots in India's agricultural economy. Where irrigation is possible, there exists enormous possibilities of agricultural achievement.

Other criticisms that I have read in public papers are that landlords are getting poorer and poorer, so that they are unable to live on their land and have to seek for their livelihood in the large cities. The Agricultural Department is blamed for being unable to show them quick and easy ways of making money out of their holdings. The Agricultural Department is also being blamed for the present state of the milk supply in the large towns of India. Now both this townward flight of the "bhadraloke" from the country and the state of the cities' milk supply have an important common factor, and that is the practical difficulty of direct cultivation on a large scale. In India, land is generally cultivated on the "batai" or share system. The actual cultivator may give up half the produce of the land to his landlord for rent. In some cases an agreement is made with a cultivator for one crop only, in other cases for a period of years. In Bengal, etc., where the Permanent Settlement holds, the landlord, unless he is also the occupier, has no power over the cropping of the land whatever. He simply collects a certain money rent annually, and so long as this rent is paid he can do nothing whatever to the land. Under such conditions it is obvious that the Agricultural Department can give him very little help. In other countries, where direct cultivation is the common practice, a considerable amount of experience, capital, technical and business ability are required to make a success of direct cultivation or stock breeding. There is nothing in India corresponding to the rent paying tenant farmer farming, say, 400 acres and working 6-7 pairs of horses and hiring agricultural labourers and piece workers. The "batai" system is of course a much simpler proposition; a tenant with a pair of bullocks will take up 10 acres of crop and, in most cases, tenants will do reasonably good work for a half share of the produce. Where direct cultivation is employed the capital required is enormously increased, large paysheets are needed, dead and live stock, agricultural machinery, etc., are all necessary, and business ability of the highest order is absolutely vital to make a commercial success of such a proposition. The examples of direct cultivation on a large scale are very few and far between in India, except in the case of plantation crops such as rubber, tea, etc., where the conditions are entirely different, involving large capital with small areas, big labour forces, intensive cultivation and trained technical staff.

It is to be noted that no educational institution can teach the business side of practical farming. A degree in agricultural science does not mean that the holder

is capable of making a financial success of an agricultural estate any more than a degree in commercial science signifies that the recipient could run a commercial business successfully.

In recent years there have been many examples of derelict companies, generally owing to the fact that the above principle has not been recognized. Direct cultivation, especially in sparsely populated areas, is a difficult undertaking. For the production of milk on modern lines, direct cultivation for producing fodder is necessary, and this is probably one of the chief reasons for the deplorable state of the milk supply in the big cities of India. The price of milk probably reaches a world's record in Calcutta and Bombay though in the district at some seasons of the year there is often a flush of milk, and these periodic flushes can only be utilized by extracting butter fat in the shape of *ghee*.

This explanation is necessary to make it manifest that not only is research required through laboratory and field experiments, but there is a crying need for practical investigation into the technique of direct cultivation in India on an estate scale.

The present constitution of the Agricultural Department in India under the Central Government consists of an Agricultural Adviser with his establishment and the following technical Sections at Pusa in Bihar:—Agricultural, Botanical, Bacteriological, Chemical, Entomological and Mycological. There is an Institute of Animal Husbandry and Dairying at Bangalore and farms at Wellington and Karnal. The Agricultural Adviser is also ex-officio Chairman of the Indian Central Cotton Committee. He is also represented on the Sugar Committee and the Cattle Bureau; at present the latter bodies are still in a transition stage.

There is an advisory body called the Board of Agriculture which meets biennially. The present Board of Agriculture is chiefly composed of official representatives from the various Provincial Agricultural Departments along with veterinary, co-operative and other officers. The Board meets alternately at Pusa and a provincial centre. Of late years it has deliberated on general questions put to it either by the Government of India or suggested by members. The proceedings are published but are not generally known to the public.

A general feeling has been expressed that some agency having a wider sphere of influence is now necessary to keep in touch with the expansion of modern agricultural methods.

Besides the education of public opinion on general questions pertaining to agriculture, there is a large field for an influential body to exercise influence on problems of national importance. With the present system of decentralization many of these problems cannot be taken in hand till public opinion can be brought to bear on vested interests. To take one example, the wheat export trade of North-West India still goes on in the old wasteful methods; bags are used instead of elevators with heavy expenditure in railways, docks and shipping and consequent lowering

in net gain to the cultivator. Very dirty wheat is exported mixed with barley, rape seed, etc., and with hard red and soft white wheat mixed.

Among the other advantages which might be expected to result from the working of some central body might be the attraction of capital to agriculture. At present both indigenous and foreign capital is very shy of agricultural projects though there is plenty of money available for special crops such as tea. India is a large exporter of raw materials, and it would be greatly to the benefit of the country if bones, fish, grain and oil-seeds were used and worked up in the country. The way to get this done is to influence public opinion. While, as already mentioned, owing to economic circumstances, many parts of India present great difficulties for immediate agricultural improvements, there are many other special areas where there is plenty of money and the time is ripe for improvement. The following heads represent the lines which urgently require exploiting in a national manner and which are common to two or more provinces or States :—

1. New and improved cultural methods.

While these are largely a work of Provincial Departments, there are many problems which would better be properly investigated by common action such as reclamation of *kalar*, *usar* and alkaline lands.

2. Irrigation facilities : both canals and wells.

National problems are the " duties of water ", water requirements of crops and data for the operation of new canals, also power well bores and drainage problems.

3. Implements and machinery.

Effort should be made to get foreign makers interested in India. The agency system at present in vogue has nothing to recommend it, and among other disadvantages stocks of spare parts of machinery sold are inadequate. A power threshing machine suitable for Indian requirement is one of the pressing problems of the day. In big wheat tracts the harvest of wheat is now beginning to interfere with the sowing of cotton.

4. Improved seeds and crops.

Under this head there are infinite possibilities.

5. Manures.

A large amount of work is required herein, especially in the utilization of manurial cakes, bones, fish, etc., which are at present exported.

6. Cattle-breeding.

India possesses some of the finest of cattle both for draught and dairy types suitable for the tropics. It also possesses what are probably some of the poorest specimens of the bovine race. India might become a large cattle supplier for the tropics.

7. Grading of agricultural produce especially for export.

Little or nothing has been done in this line in the past. Other countries have put their house in order, as witness the dairy and fruit trade in Australia, graded and supervised by Government, also Canadian graded wheat; most of India's products are a by-word for dirt and inferiority in the world's markets.

8. Educational.

Education of the right stamp of men with some knowledge of conditions in several provinces is essential for the eventual establishment of an Indian Agricultural Department staffed by Indians. Modern dairy and cattle works can also conveniently be dealt with by some central establishment.

These briefly are some of the lines of work which can only be adequately dealt with by some organization run by the Central Government and having adequate means and staff at its disposal.

The constitution and object of the proposed central organization will have to be worked out in detail. It will be essential to have a permanent Secretary and Board of Directors and the headquarters will have to be in touch with the Government of India. Transactions should be published perhaps based on the present *Agricultural Journal of India*.

It may be found possible and desirable to hold an agricultural show on a scale properly representative of the magnitude of Indian agricultural interests.

There are many models to choose from in various countries such as the United States Department of Agriculture which is largely executive in character. In the United States of America the Federal Government corresponds to the Government of India, while each State has its own machinery corresponding to the various provinces of India, so conditions are somewhat analogous.

As noted above, the fact that agriculture has been made a transferred subject under the Provincial Councils, entails a certain amount of difficulty in organizing a central co-ordinating authority. The newly elected Legislative Councils may consider that the provincial aspects of agricultural improvements are more important to them than any ideas of national significance. It is essential therefore that it should be clearly laid down at the beginning that there will be no attempt to interfere in any way with the domestic policy of any province. On the other hand, as soon as a problem becomes of importance to two or more provinces or Indian

States, it is essential that this problem must be dealt with by some central representative body.

It would also be desirable that provision should be made in the central body to give adequate representation to provincial interests.

My personal opinion is that the organization of the Department of Agriculture of the United States of America should be closely studied, and a similar organization elaborated for India with such modifications as are necessary owing to different conditions. In the United States, there are State Departments of Agriculture which are analogous to the Provincial Departments of Agriculture in India. There is a Federal Department which is financed by the Central Government. A modification of this system might possibly be found necessary, *viz.*, to incorporate a strong propaganda and advisory section of the Central Department; on this local landowners and private zemindars and others interested in agriculture could be enrolled.

It would also be essential to enlist representatives of the trade interests. In the case of India this is comparatively simple as the particular trades are localized. The trade interests would be better represented by the formation of Committees and Central Bureaus on the model of the Central Cotton Committee stationed at Bombay. Each important crop might have a similar organization and so also cattle and manures.

The central body could delegate its authority to a considerable extent to these various bureaus and committees when they are in working order.

THE WILT DISEASES OF COTTON AND SESAMUM IN INDIA.

BY

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The occurrence of wilt diseases of cotton and sesamum in India has been frequently recorded, and the purpose of the present paper is to describe some unpublished work on them carried out in 1912, and to discuss briefly the relationships of some Indian wilt-producing fungi.

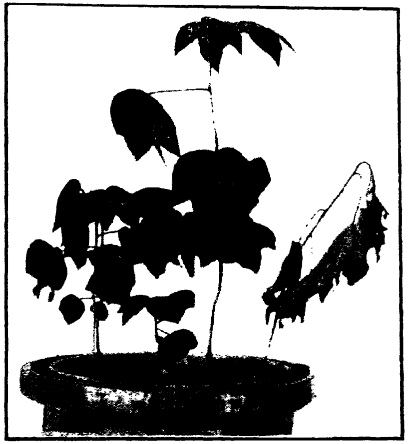
COTTON WILT.

Fresh material of cotton wilt was selected by the writer from a field of Jari cotton at Matargaon village in the Berars, India, on 2nd October, 1912. There was a large patch of wilted plants in this field, and the specimens were taken from five plants in an early stage of the disease, each of which had still some of the leaves green.

Isolations were attempted on the same day from each of the plants by washing a piece of infected tap root in several changes of sterile water, dipping in absolute alcohol, flaming off the alcohol, and dropping into prepared tubes of medium or into sterile Petri dishes. Microscopic examination of adjacent sections of the root showed in each case the presence in the vessels of hyphæ resembling those found in the wilt disease of pigeon pea (*Fusarium udum*). Growth was obtained on the 5th from three of the plants thus treated, the pieces of root from the other two remaining sterile. Subcultures were made on nutrient agar from the roots of these three plants on the same day. The fungus was similar microscopically on all three and was found in two cases to be bearing micro- and small macroconidia of a *Fusarium*, while the third had no spores on the young piece of the mycelium examined. On returning to Pusa on 17th October, good growth was found in the subcultures from two of the plants, that from the third being sterile. The fungus was similar in both cases and was a *Fusarium* with numerous microconidia and a few macroconidia. Later on large quantities of chlamydospores developed in the tubes; in cultures these were collected into stromatic, nodular masses. The inoculations described below were from one only of these isolations.

On 1st August, 1913, four culture pots that had been sterilized after filling by heating in the pressure boiler of the Pusa pot culture laboratory were inoculated by adding to the soil a suspension in distilled water of this fungus from a pure culture

Fig. 1. A wilted and healthy cotton plant growing in inoculated soil.



A wilted and four healthy cotton pl
growing in inoculated soil.

Fig. 3. Inoculated and control pots of sesamum, former attacked by wilt.

six days old. On 2nd September they were sown with Bani cotton seed sterilized by soaking in 0·25 per cent. formalin for three hours, a fresh suspension of the fungus from a culture of the same date as the last being added around each seed. Two other pots similarly treated, except that they were not inoculated, served as controls. Six more pots that had been sterilized after filling on 29th August were sown with the same seed on 2nd September, four being inoculated from the culture last mentioned by adding a suspension around the seed, and two left uninoculated. Thus four of the pots had received a double inoculation, one to the soil a month before sowing and a second with the seed, while four had received the latter only, and there were four controls. Germination was poor and all the pots were resown with sterilized seed of the same variety on 17th September. The first case of wilt in the inoculated pots was observed on 23rd October, and from that time until 18th December, when observations ceased, cases continued to occur sporadically in five of the inoculated pots. No cases occurred in the other three inoculated or in the control pots, one of which was noted as having 11 healthy plants, 6 to 8 inches high, on 29th November. The conditions in four of the pots are described in detail below.

In a pot containing three plants, one of these plants, about 6 inches high and with about 6 leaves, began to wilt on 10th November and it died in the next few days. A second began to droop on 17th November and was dead two days later. It was removed and sectioned. The lateral roots were little altered except for some brown stains, especially marked near the junction with the tap-root. The latter was not outwardly affected. The collar was shrunken. Hyphæ and chlamydospores were present in the vessels about 1 inch above soil level, but were not numerous. Mycelium was also found in the tissues 1½ inches below the soil chiefly in the vessels and in the centre of the central cylinder. At 3½ inches below the soil, the tap and lateral roots were free from fungus. A microconidium was found in a vessel near the soil level. The fungus was recovered in a manner similar to that followed in the original isolations, and pure cultures on nutrient agar secured. It resembled the fungus used in the inoculations and yielded micro- and macroconidia and chlamydospores.

On 16th November one plant in a second inoculated pot, in which there were also a large plant (9 inches high and with about 8 leaves) and a smaller seedling, both quite healthy, began to wilt, and wilting was complete on the 19th when the small seedling was pulled out and the pot photographed (Plate XIII, fig. 1). The other two plants were then removed and sectioned. No trace of fungus infection was found in the tap-root, collar, or stem of the healthy plant, while in the other there was strong infection extending from the stem above ground to the fine part of the tap-root about three inches below. The vessels were in places almost blocked with a dense, matted growth of hyphæ, and numerous microconidia were found in them. The fungus was recovered as before and pure cultures bearing micro- and macroconidia and chlamydospores were obtained.

On 23rd November a strong plant about 8 inches high, in a third inoculated pot in which there were 4 other quite healthy plants, began to droop. The pot was photographed on the 26th (Plate XIII, fig. 2), and the next day the wilted plant (which was still quite green but flaccid and exactly as if it was wilting from lack of water) was removed and examined. Hyphæ were found in the vessels an inch above soil level and in much greater quantity three inches lower down. The lateral roots in this, as in most of the other cases, were externally quite unaltered. At $3\frac{1}{2}$ inches below the soil hyphæ were rare in the tap-root. On 1st December a second plant in this pot began to wilt and by the 5th it was quite dead, while on 17th December the biggest plant in the pot wilted and all its leaves were drooping on the next day, when observation ceased, the two remaining plants being still quite healthy.

On 10th November the only plant in another pot began to wilt. It was about 6 inches high and had 6 leaves. Three days later it was removed and sectioned. Hyphæ with some microconidia were present in the vessels in the neighbourhood of the collar, but the lateral roots were for the most part white and sound. It appeared to be a typical case of cotton wilt. The pot was resown on 17th November and three seedlings came up. One of these wilted on 8th and another on 16th December, one being still quite healthy two days later when observation ceased.

The first three cases described above belonged to the batch of pots that had received a double inoculation, while the fourth had only received one. Two plants out of seven wilted in another pot of this latter batch, but no deaths that could be definitely attributed to wilt occurred in one pot of the first batch and two of the second. Thus the percentage of deaths from wilt in the inoculated pots was low and the incidence of the disease was irregular, some plants escaping altogether while others succumbed, though all must be considered to have been exposed to the same intensity of infection. Nevertheless, those that became infected died in the manner characteristic of the *Fusarium* wilts, the examination of a large number of wilted plants in the field supported this conclusion, and the capricious results of the inoculations would appear to be due to the action of some factor which aids or hinders infection by the fungus. That this factor cannot be a soil one is highly probable from the fact that the one batch of soil was used for each of the two series, while even in the same pot some plants wilted with heavy infection though others survived and were free from internal hyphæ.

The experiments above described do not solve the problem of cotton wilt in Central and Western India. They would not have been published as they stand were it not that circumstances render it unlikely that the writer will be able to do any further work on the disease. It is believed that they show that the disease is caused by a *Fusarium* which is capable of pathogenic action under certain conditions not yet elucidated, and that these conditions are probably not connected with the composition of the soil, as has been suggested by J. F. Dastur.[1]

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[1] *Agri. Jour. of India*, Vol. XIX, pp. 251-260, 1924.

SESAMUM WILT.

Isolations were made from wilted seedlings of sesamum (*Sesamum indicum*) about 6 weeks old and 4 to 6 inches high at the Hoshangabad experimental farm, Central Provinces, India, on 28th September, 1912. The isolations were made in the same way as those already described in the case of cotton wilt, and a pure culture on nutrient agar was brought back to Pusa and subcultured on 17th October. The fungus was a *Fusarium* with all types of spore from oval, cylindrical, or falcate, continuous microconidia to fusiform or slightly falcate, pluriseptate macroconidia. Chlamydospores were numerous, single or in chains, round or pear-shaped, colourless, and charged with distinct fat droplets.

On 1st August, 1913, a subculture of this fungus, six days old, was used to inoculate four pots of sterilized Maghai sesamum, the filled pots and the seed having been sterilized as in the cotton wilt work except that the seed was immersed in 0·25 per cent. formalin for only two hours. After sowing, but before covering, a suspension of the fungus in distilled water was poured over the seed. Two other pots similarly treated but without inoculation were kept close by as controls.

On 8th August a seedling in one of the inoculated pots collapsed at the collar, and next day cases of wilt were observed in all but the control pots. On the 11th the four inoculated pots had respectively 10, 7, 12, and 8 plants healthy, 1, 1, 0, and 3 dying and 5, 5, 6 and 7 dead, while the two controls had a number of healthy seedlings and only one dead. On the 14th there were 1, 3, 2 and 1 healthy, 0, 3, 0 and 0 dying, and 15, 7, 16 and 17 dead in the four inoculated pots, while in the controls three more plants had begun to wilt. By the 20th all the seedlings had died of wilt in the inoculated and in one of the control pots, which had 30 plants, while in the other control, with 23 plants, all were healthy. The deaths were similar throughout; brown stains showed at the ground level and the plant rapidly became flaccid and fell over. They were quite obviously due to virulent attack by the fungus, which was forming spores freely on the surface of the affected plants and had spread to one of the controls which was standing alongside the inoculated pots.

On 2nd September the five pots in which all the seedlings had wilted were resown with sterilized seed as before, a fresh inoculation being made by adding to water poured around the seed a suspension from a culture of the same date as that previously used. Six more freshly sterilized pots were also sown on the same day in the same manner as in the first experiment. Three of these were inoculated as before and three kept as controls. The latter were placed in an isolated position in another building at a distance from that in which the inoculated pots stood. Germination was very good and the first case of wilt was observed in one of the resown pots on 7th September. On the next day there were in the five resown pots 39, 28, 48, 35 and 35 seedlings respectively, of which 3, 0, 6, 2 and 1 were wilting; in the newly-sown inoculated pots there were 39, 26 and 33 seedlings all healthy, and in the controls a large number also all healthy. The first case of wilt in the newly-sown pots occurred on the 9th, and next day there were several cases in each of the three

inoculated pots of this batch. The photograph in Fig. 3 (Plate XIII) was taken on the 15th and shows the contrast between an inoculated pot (that which had 48 seedlings all of which but 3 or 4 were now wilted) and a control with 45 seedlings, all healthy. By 23rd September all were dead in the inoculated pots except in one of the freshly-sown ones in which 4 were still alive, while all were healthy in the controls.

Several apparently healthy seedlings were removed from one of the newly-sown inoculated pots on 16th September and examined. They showed red markings at the collar about the junction of root and stem. Hyphæ were present in the epidermis and cortex at this level but none had penetrated the endodermis. On young seedlings such as those exposed to infection in these experiments the parasite kills more in the manner of the damping-off fungi than in that characteristic of the vascular wilts. Its main development takes place in the parenchymatous tissues and it forms, under suitable conditions of moisture, a considerable growth of hyphæ and spores on the collapsed aerial parts of the shoot. On older plants, specimens of which have been examined from time to time, the disease is more like a typical wilt such as that caused by *Fusarium udum*, and in such cases entry is probably through the finer roots, extension upwards occurring through the vascular system.

Whether the disease is the same as that in Turkestan sesamum described by Jaczewski (*Annales Mycologici*, I, pp. 31-32, 1903) and attributed by him to *Neocosmospora vasinfecta* cannot at present be determined. Jaczewski's description is brief and purely morphological, so that it would be scarcely possible to do more than recognize his fungus as a *Fusarium* probably of the *Elegans* section of the genus were it not that, shortly after, Bessey gave fuller details of what was evidently the same fungus, which he isolated from wilted sesamum plants similarly received from Turkestan. His cultural studies (*Flora*, XCIII, pp. 301-334, 1904), joined to Jaczewski's morphological description, leave practically no room to doubt that the Turkestan sesamum wilt is caused by the same fungus as that in India. Although the latter author determined the parasite as *Neocosmospora vasinfecta*, and Bessey found great similarities in its cultural characters with those of that fungus, subsequent work both in India and the United States enables us to exclude the latter from consideration.

The study of a new series of cultures from wilted sesamum plants, which I owe to the kindness of Mr. J. F. Dastur, Mycologist to the Central Provinces Government, Nagpur, has not only enabled me to follow the colour changes described in such detail by Bessey, but has also brought out many points of similarity to other species of the same section of the genus. Comparison with *F. cubense*, the cause of the Panama disease of bananas, revealed no constant morphological or cultural differences. Furthermore, I have vainly endeavoured to find a true distinguishing character between the sesamum fungus and *F. udum*, described by me in 1910 as the cause of the pigeon pea wilt in India (*Mem. Dept. of Agri., India, Bot. Ser.*, II, 9). Small has recently studied in great detail what he considers to be *F. udum*, which he found attacking a number of different plants in Uganda (*Kew Bull.*, 1920, p.

321 ; 1922, p. 269 ; 1925, p. 118). Hence, though in India the strain of *F. udum* parasitic on pigeon pea seems to be restricted to that host, in Uganda the morphologically and culturally similar fungus is capable of attacking not only pigeon pea but a considerable number of other plants, and this strengthens the possibility that the sesamum parasite may be merely another strain of the same species.

Fusarium udum itself was named without prejudice to the question whether it had not been previously included amongst the named members of the genus. The chief diagnostic characters were the pionnotal type of sporulation, the flesh to salmon-pink colour on many media with absence of blue colours, and the tubercular stromata on potato and plantain. Subsequent isolations at Pusa, however, showed that the first of these characters was not constant, some strains giving a copious aerial mycelium on agar slants. Nodular sclerotia also are now known to be commonly produced by many members of the genus and occur in both *F. cubense* and the sesamum parasite, in which they are blue on potato but gradually turn pink if placed in lactic acid. Bessey's conclusion that the red and blue colours are only chemical modifications of the same pigment has been substantiated by subsequent investigators, and there seems every probability that the blue or violet colours developed in *F. cubense* and the sesamum fungus could also be produced by *F. udum* on suitable media. Small, indeed (*Kew Bull.*, 1922, p. 282), obtained a pale blue pigment in his strain in two cultures.

Recently, Hansford, confronted with the difficulty of distinguishing *F. cubense* in culture from many other strains of the *Elegans* section of the genus, has concluded that the present classification of the section is useless and that the conception of a species of *Fusarium* must be broadened (*Proc. 9th West Indian Agri. Conf.*, 1924, pp. 43-44, 1925). He considers that it is preferable to regard all the *Ele ans* forms which he has encountered as strains of a single species. With this view, my own observations are in harmony, and I now regard *F. udum* and the two forms discussed in the present paper as strains of the same species. Furthermore, *F. cubense* is so similar to the sesamum fungus that it can scarcely be considered as a distinct species, either on morphological or cultural characters. It appears to possess strains differing in their selective parasitism, *Musa cavendishii* being immune from it in the West Indies but susceptible in the Canaries. Finally, through *F. cubense*, which both Brandes and Woollenweber have noted to be scarcely different from *F. vasinfectum*, one is led to include the latter in the group of closely allied strains. In so doing I have reversed my previous opinion (*Rept. Agri. Res. Inst. and College, Pusa, 1913-14*, p. 54, 1914) which was based on cultural differences between the American and Indian cotton wilt fungi, these differences being now regarded as too inconstant to be used as satisfactory criteria.

Thus the wilt-producing fungi attacking cotton, sesamum, and pigeon pea in India may, in the writer's opinion, best be considered to be strains of *Fusarium vasinfectum* Atkinson, which itself may be merely a strain of one of the earlier described species of the genus.

THE STUDY OF THE COTTON FIBRE.*

BY

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SUMMARY.

THE paper is divided into three sections: (1) Structure and Composition; (2) Physical and Chemical Properties; and (3) Practical Aspects. In the first section a general description of the fibre is supplemented by an account of the recent work of Balls and Denham, and, in particular, of the former's view that the cell-wall of the cotton fibre consists of about 25 layers each consisting of about 40 fibrils running spirally from one end of the fibre to the other. The second section deals in some detail with recent work upon those properties of raw cotton which are considered to have an important practical aspect, *viz.*, (1) Length; (2) Ribbon width; (3) Area of Cross-section; (4) Wall-thickness; (5) Weight; (6) Strength; (7) Tensile elasticity; (8) Surface friction; (9) Torsional elasticity; (10) Plasticity; (11) Lustre; (12) Electrical conductivity; (13) Porosity and permeability; (14) Physical and chemical stability. It is pointed out that considerable difficulties arise in the measurement of these properties owing to the irregularity of the material. From irregularities in a single cotton fibre we proceed in an ever-widening circle of irregularity as we extend our consideration in turn to fibres from a single seed, a single boll, a single plant, a single variety in a given locality, different varieties in different localities. In the final section the general relationship of the various properties to practical problems of the cotton industry is briefly discussed. Emphasis is laid upon the difficulties besetting the interpretation of these properties in terms of practical utility and, as an example, their relation to the spinning value of a cotton is discussed in some detail.

In the present paper I propose to review the results of the more recent work on the cotton fibre with particular reference to their bearing upon the problems of the cotton industry. For convenience of treatment we may consider the subject in the following sections, which will be dealt with *seriatim* :—

(i) Structure and Composition.
(ii) Physical and Chemical Properties.
(iii) Practical Aspects.

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* Paper read at the Indian Science Congress, Bombay, 1926.

I. Structure and composition.

A good deal of work has been done at one time or another on the structure of the cotton fibre. A good critical summary of this up to 1922 is given by H. J. Denham (10)*. Supplementing this by the later work of Balls (8, 9) and of Denham himself (11) we arrive at the following description of the cotton fibre: The cotton fibre is botanically a seed-hair; it consists essentially of a more or less flattened ribbon which is thicker at the edges than at the centre, and which is sometimes crescentic or even more irregular in section. The ribbon is about an inch long, and rather less than one-thousandth of an inch in width-dimensions which are capable of very wide variations, not only in different types of cotton, but even in a single type. Perhaps the most characteristic feature of the fibre is the occurrence of numerous twists along the length of the hair, amounting to 100 or more dispersed at irregular intervals along the length, sometimes in one direction (clockwise) and sometimes in the other direction (anticlockwise) in one and the same fibre. These general characteristics have been familiar to microscopists since the time of Leuwenhoek, 1678. Controversy has been excited about the more intimate features of the fibre: it is simplest to study this, not from a chronological standpoint, but from that of the development of the fibre so clearly described by Balls (2). The fibre results from the growth outwards of an epidermal cell of the seed-coat; even before fertilization of the ovule takes place it is distinguished from its neighbours by a slight protrusion, yet in other features it is quite similar to them; it has a very thin cell-wall (the primary wall). After fertilization takes place the hair elongates at the rate of about 1 mm. per day, or as Balls puts it, the length increases by about twice the value of the diameter every hour, the diameter itself remaining quite unchanged. This goes on for about 25 days; growth in length then ceases and, instead, the cell-wall begins to thicken from the inside inwards, so that the diameter still remains the same. Thickening of the wall (secondary thickening) proceeds for about 25 days, the result being a considerable diminution in the free space inside the hair. At this stage no further growth occurs either of the hair or of the seed or of the boll containing the seeds;—the boll then opens, the protoplasmic contents of the cotton fibre die through desiccation, and are deposited on the inner walls of the fibre, and the fibre develops its characteristic convolutions. We perceive then that the principal features of the fibre are:—

(1) Primary wall (including cuticle);
(2) Secondary thickening (cellulose);
(3) Cell contents (protoplasm, nucleus, colouring matter);
(4) Convolutions.

Another interesting feature is the existence in many varieties of a length towards the apex of the fibre, in which there are no convolutions and practically

* The figures in brackets after the names of authors relate to the references given in the Bibliography at the end of the paper.

no central canal, the whole of the interior being occupied by secondary cellulose. Such lengths are known as " tails." It has been stated that these tails break off in the preparatory processes of spinning, but so far this view has not been definitely proved.

The exact structure of the primary wall cannot be stated with certainty. It may consist of an outer layer of cuticle with an inner layer of primary cellulose (or " pre-cellulose " in the early stage) or the primary wall may be wholly a modification of cellulose having dispersed through its mass substances of a fatty nature which make it resistant to wetting and desiccation. The general concensus of opinion favours the former view.

The cellulose laid down as secondary thickening constitutes the characteristic cotton cellulose. The manner of deposition of this secondary cellulose has been a matter of considerable speculation and controversy. In 1919 Balls (7) proved experimentally a theory he had advanced in 1912, and showed that the secondary cellulose consisted of concentric layers of cellulose, about 25 in number, each layer having an average thickness of $0{\cdot}4\mu(\mu=0{\cdot}001$ mm.), and representing one night's deposition. In a later paper Balls and Hancock (8) carry the matter a stage further and conclude from their microscopical evidence that the secondary cellulose consists of spiral fibrils running the whole length of the cotton fibre, each of the 25 layers consisting of about 40 continuous fibrils. This view is contested by Denham (11), who maintains that all the evidence can be satisfactorily explained on the more generally accepted theory of lamellar deposition, the fibrils on this view being merely localized spiral thickenings in continuous layers of the secondary cellulose. His observations on the spirality of the secondary layers conflict with those of Balls; Balls states that all the fibrils of the successive secondary layers follow the same course as the corresponding fibrils of the primary wall; Denham contends that in many cases this is not so, and that the spirality of the secondary layers may not only be at different angles, but may even be in the opposite direction to that of the primary wall. In a still later paper Balls (9) adduces further and what appears to be conclusive evidence in favour of his own view, based on observations in which he used elliptically polarised light to examine longitudinal sections. And here for the present the matter rests.

So much for the chief features which can be traced in the development of the fibre. But how, it may be asked, are the characteristic convolutions (twist) to be explained? Balls (3, 8, 9) explains them as an inevitable consequence of certain pits he had observed as universally present in the young fibres: these pits, he concluded later, were merely gaps between the otherwise contiguous fibrils; they run spirally at intervals and form lines of weakness in the fibre, so when the boll opens desiccation of the fibres takes place and they collapse along these lines of weakness, thereby receiving this twisted appearance. Denham (11) has not been able fully to confirm Balls's observations of these pits, which he considers as more probably due to a double line of weakness recurring on two or more superposed layers of the

secondary cellulose. Denham also maintains that there are at least four kinds of convolutions—(*a*) Normal, (*b*) Movable, (*c*) Preformed, and (*d*) Suppressed. Normal and movable convolutions are derived from the spirality already discussed, the latter differing from the former only in disappearing as the fibre becomes moist. The distinction appears to be a questionable one. Preformed convolutions are bends and kinks due to the fibres being inhibited from growing straight both by lateral pressure from adjacent fibres and by the boundary surface presented by the expanding boll; preformed convolutions are a source of weakness in a fibre. Suppressed convolutions are such as hardly affect the surface of the fibre, but give it the appearance of a fluted rod.

Besides the major characteristics already discussed there are various features which may assume considerable importance in their practical aspect. Among these are the rows of pores which De Mosenthal described in 1904, referred to by Denham as "beaded pits," and by Balls as "slow (or slip) spirals," in contradistinction to the general spirality described by him as "quick (or pit) spirals." These slow spirals are superficial effects, not penetrating far into the wall; they are really slip planes due to stresses acting on the fibres after the boll has opened; they are consequently most abundant on fibres of old cotton material, especially that which has highly stressed—such as much-used cotton string. Slip-planes of a different character, as well as corrugations and buckling lines in the surface of the fibre, are however produced as a result of the crowding of the fibres in the boll. All such features may be of importance in the dyeing of cotton, as well as in its infectivity by fungi and bacteria. One other feature may be referred to, *viz.*, certain "bulges" in the fibres; they are possibly important because they are sources of weakness.

Composition.

The chemistry of the cotton fibre has long been a favourite subject of study. An excellent summary of the literature has been prepared by Fargher and Withers (13) who concluded that a good deal of work would be necessary to establish the identity of the different constituents. The composition of a Surat cotton determined, along with that of many other cottons, by Church and Müller, is fairly representative of all their results :—

Surat cotton.

	Per cent.
Cellulose	91·35
Wax	0·40
Protoplasm, etc.	0·53
Ash	0·22
Water	7·50
	100·00

The results which other observers have obtained differ very appreciably from these, however, for example, Barnes has found the ash of a Bombay cotton to amount to 2·23 per cent.—more than ten times that given by Church and Müller. The mineral element present in largest amount was potassium (K_2O : 27·3 per cent.) with silicon (SiO_2 : 15·6 per cent.), aluminium (Al_2O_3 : 10·8 per cent.), calcium (CaO : 9·7 per cent.), and sodium (Na_2O : 4·5 per cent.) in decreasing proportions. Of acid radicles there were CO_2 (12·2 per cent.), Cl (6·5 per cent.), P_2O_5 (3·3 per cent.) and SO_3 (2·0 per cent.). I may add that a determination of ash of Surat 1027 A.L.F. in the Technological Laboratory gave a value of 1·45 per cent.

It is interesting to note that Crace Calvert's determinations of the percentage of soluble phosphate, calculated as P_2O_5, gave for practically all the cottons examined a value of 0·050 per cent., a notable exception being Surat cotton with a value 0·027 per cent. The later work of Geake (16), however, does not bear this out, for he has found that Egyptian cottons have a decidedly higher content of phosphorous ranging from 0·077 per cent. to 0·134 per cent. and averaging about 0·1 per cent. P_2O_5, whereas various American cottons have values ranging from 0·042 to 0·061 per cent. and averaging about 0·05 per cent. P_2O_5 (a figure which agrees with Crace Calvert's general figure). Indian cottons were more variable, ranging from 0·054 per cent. for Oomra No. 1 cotton to 0·124 per cent. for a Broach cotton. Geake claims that his results show that it is possible to distinguish Egyptian and American cottons by means of their phosphorous content. It is noteworthy that the results for phosphorous content have been found to parallel those for the absorption of methylene blue (16·14). Similar differences of a less pronounced nature have been found by Ridge (17) in the nitrogen content of various cottons.

Some of the most interesting results of the recent work have attended the investigation of cotton wax (18, 19, 20, 21, 22, 23). The composition has been found to be much the same for all varieties, consisting chiefly of mixtures of two newly-discovered alcohols—gossypyl alcohol ($C_{30}H_{62}O$) and montanyl alcohol ($C_{28}H_{58}O$), present in the free state, together with carnaübic acid ($C_{21}H_{48}O_2$) present as an ester. There is a large number of other alcohols and acids present, as well as some hydrocarbons, but these are in much smaller amount. For different growths of cotton the total amounts and also the proportions of the various substances differ somewhat.

II. Physical and Chemical Properties.

It is evident that the physical and chemical properties of cotton determine the behaviour and so the value of a cotton in manufacturing processes. At the same time the physical and chemical properties are themselves an expression of the structure and composition. But to formulate this expression in concrete terms is no easy matter. A knowledge of the physical properties of the several constituents is useful, but does not carry us very far, because in actual practice we are concerned

with the aggregate effect, which may be and usually is largely determined by the amounts and relative proportions of the constituents and the manner of their distribution. As we have seen, the structure and composition of even a single fibre are exceedingly complicated. Irregularity often exists in the properties of one and the same fibre at different points. Still greater irregularities are found as we proceed to consider in turn a number of fibres from a single seed, a single boll, a single plant, a single pure strain, a single variety, different varieties in different localities. Bearing this in mind, we may now turn to those properties which would appear to be of importance practically ; these are :—

1. Length.
2. Ribbon-width.
3. Area of cross-section.
4. Wall-thickness.
5. Weight.
6. Strength.
7. Tensile elasticity.
8. Surface friction.
9. Torsional elasticity.
10. Plasticity.
11. Lustre.
12. Electrical conductivity.
13. Porosity and permeability.
14. Physical and chemical stability.

The above list is of course by no means exhaustive ; it serves however to emphasize those properties which are more obviously of practical importance in the processes of spinning, weaving, mercerising, bleaching, dyeing or finishing. Attention in this paper will therefore be confined to these properties. It must be emphasized once more, however, that none of these properties is uniform, even in a pure strain of any particular variety of cotton. It follows that it is impossible to characterize a given cotton as having a certain length ; indeed for such a property as ribbon-width different values are obtained at various points along the length ; all that can be done therefore for a given variety is to refer to the dispersion of the values obtained and to some statistical average. In other words, the whole problem must be treated statistically. This makes the interpretation of the results, even when obtained, far from easy : this matter of the interpretation will be discussed in the next section. There are other disturbing factors which may assume the greatest importance. These are the physical conditions prevailing when the measurements are made. Of these the most important are the humidity and the temperature. So great is the magnitude which the humidity factor almost invariably assumes, that it may be taken as a general rule that observations taken without reference to it are valueless. The relation between the cotton fibre and water or

water vapour is not a simple one as the large amount of literature on the subject amply testifies (28, 29, 30, 31, 32, 33).

A general review of the physical properties of cotton cellulose by Collins (27) discusses generally those of the fibre itself; seventeen different properties are considered, most of which are not included in the list given above of properties of practical importance, to the more detailed consideration of which we may now proceed.

1. *Length.* The obvious simple scientific methods for the determination of length are very tedious to perform. They involve the straightening of single fibres, fixing them in some convenient manner, and then measuring them. A great number of observations is necessary, and from the results we can only deduce the percentage numerically of various lengths. To obtain the proportion by weight, and this is of greatest interest practically, weighments are necessary. The whole procedure has been simplified by the invention of two machines which enable the percentage composition of staple length to be determined more or less mechanically. These are the Balls Sorter (43) and the Baer Sorter. Although quite different in their mechanism, they both depend for their action on bringing to a common line one end of each fibre in a group; in the Balls Sorter this is effected by a pair of rollers which first nip the end of a fringe, and then, by their traverse along a strip of plush, deposit the fibres thereon according to their length, because the revolution of the rollers causes the fibres gradually to pass between them and as the shorter fibres come to their other end first they are necessarily deposited first. It only remains to gather the fibres between length intervals and to weigh these various parts of the deposit, to get the weight-distribution of the different lengths. With this Sorter it is very necessary to have the fibres thoroughly disentangled when presented to the machine, otherwise fibres not actually in the nip of the rollers at the beginning may be dragged through by others which *were* in the nip, and erroneous results will ensue. With the Baer Sorter more depends upon the individual. A sliver is laid across a number of combs and the worker nips the ends of a number of protruding fibres in a special nipper, and then proceeds to place the group of fibres across the combs again in a different place, the nipper resting against the back comb. He repeats this operation a number of times and so obtains a bunch of fibres all of which have one end along a common line—that of the back comb. Obviously those which are longest will stretch furthest across the combs, and he now therefore selects them by nipping the distant ends, taking the longest first, and building up a diagram of even density, the length of the fibre being the ordinate, the abscissa depending upon the length-distribution. From this diagram the mean and the modal lengths can easily be obtained, and, much less readily or accurately, the fibre-length distribution. The following are some values which have been obtained in the Technological Laboratory on the two Sorters for various Indian cottons.

TABLE I.

Sorter results for standard Indian cottons.

Mean group length in eighths of an inch	Dharwar No. 1	Gadag No. 1	Surat 1027 A.L.F.	Punjab 4 F.	Punjab 285 F.	Punjab 289 F.	K. 22	Cawnpore C.A. 9	J.N. 1	Aligarh A. 19	Coimbatore 1	Nandyal 14	Hagari 25	Karunganni	Umri Bani	Mississippi	Texas
2	0·0	0·2	0·1	0·0	0·2	0·0	0·4	0·0	0·6	0·3	0·0	0·3	0·0	0·1	0·3	0·2	0·0
3	1·4	1·6	0·5	2·1	0·9	1·5	1·6	1·2	1·9	2·1	0·6	1·3	1·6	0·7	1·6	1·3	1·1
4	3·4	3·4	1·6	5·5	1·9	2·3	4·6	2·5	4·8	7·8	1·5	3·0	3·4	1·5	3·7	2·3	3·1
5	7·9	6·3	3·8	12·5	3·5	4·6	14·0	6·2	13·2	21·4	3·0	6·3	7·7	4·0	8·8	4·6	8·3
6	16·8	13·0	9·2	27·5	6·9	7·9	33·5	14·0	33·4	42·8	6·3	11·1	15·4	11·5	21·2	11·0	21·5
7	32·4	28·6	18·3	34·3	12·3	16·0	33·4	31·0	35·3	21·7	13·7	25·6	29·2	23·2	38·6	22·7	36·8
8	26·1	31·3	26·9	13·9	21·2	25·4	10·3	33·6	9·5	3·8	25·5	36·3	25·0	32·7	20·9	25·7	20·3
9	10·2	12·8	22·5	3·5	27·5	24·2	2·2	10·7	1·3	0·1	27·8	14·8	13·1	19·6	4·2	20·0	6·7
10	1·4	2·5	12·7	0·7	18·2	12·8	0·0	0·8	0·0	0·0	15·7	1·3	4·1	6·7	0·7	8·6	1·9
11	0·4	0·3	4·4	0·0	7·4	4·1	0·0	0·0	0·0	0·0	5·9	0·0	0·5	0·0	0·0	3·2	0·3
12	—	—	—	—	—	1·2	—	—	—	—	—	—	—	—	—	—	—
Mean staple length (inch) (Balls Sorter)	0·88	0·90	1·00	0·81	1·04	1·01	0·79	0·90	0·78	0·74	1·04	0·91	0·90	0·95	0·84	0·97	0·86
Mean staple length (inch) (Baer Sorter)	0·90	0·91	1·01	0·81	1·05	1·01	0·78	0·91	0·78	0·72	1·05	0·91	0·90	0·95	0·86	0·98	0·85

2. *Ribbon width.*
3. *Area of cross-section.*
4. *Wall thickness.*

These are dependent upon magnification for their measurements. They can be measured by the use of the microscope, either directly or indirectly or by a projection method.

Calvert and Harland (46) describe a method which they claim makes it possible to restore the cotton hair to something like its original conformation, in which state measurements of the actual diameter may be made. The method consists in treating the fibres with 40° Tw. sodium hydroxide. The fibres are then mounted in liquid paraffin and drawings made at a magnification of 1200 diameters with the aid of a *camera lucida*. The following are a few of the mean values for diameter recorded by them for fibres thus treated :—

TABLE II.

Diameters of cottons.

Cotton	Diameter (mm.)
Sea Island (Gr. Vincent)	0·012
Sakellaridis	0·013
Punjab American 285 F.	0·015
,, ,, 289 F.	0·015
,, ,, 4 F.	0·017
Surat 1027 A.L.F.	0·013
Texas	0·018

Some values for ribbon-width which have been obtained in the Technological Laboratory are given with the results for convolution determinations in Table IV below. The other properties will be discussed in connection with the weight and strength of the fibres.

5. *Weight.*
6. *Strength.*

Balls after mentioning (3) that the "components which could affect the weight of a lint hair are its length, the thickness of its wall, the density of the cellulose of which the wall is composed, its diameter, and its moisture content," concludes that, in general, "the weight of a hair will depend on its diameter and the thickness of its wall." Having found that the ratio of the fibre weight to the breaking load had a value ranging from 2·60 to 3·26, he concluded that the breaking load of a hair is largely determined by its weight, *i.e.*, by its diameter and wall thickness. Harland and his co-workers, in making a number of determinations of the measurable characters of raw cotton, included that of the hair weight per centimetre (44), cutting one centimetre lengths from the middle of a bunch of fibres by means of a cutter consisting of two safety-razor blades fixed one centimetre apart, and then weighing the fibres in groups of 40 on a microbalance. The mean values obtained for a series of five cottons varied from 0·0015 milligram for an American cotton to 0·0027 milligram for a Peruvian cotton; they found the areas of the cross-section of these two cottons to be 0·00014 mm.^{2} for the American cotton and 0·00027 mm.^{2} for the Peruvian cotton. From their figures for area of cross-section and of fibre weight per

centimetre they calculated the density of cotton; this came out at about 1·1 instead of the usually accepted value of 1·5. They deduce therefore that the apparently solid mass of cell wall is a porous structure—in harmony with Balls' views of a fibrillar structure—and that the pore space present varies from 32 per cent. to 41 per cent., the amount tending to increase with the coarseness of the cotton.

A later paper by Miss Clegg (45) dealt with the breaking load of single fibres, the correlation of the breaking load with convolutions, wall thickness, etc., and the breaking load of single fibres of three of the cottons after mercerisation. For the determination of the breaking load O'Neill's method was used. This consists of suitably fixing the upper end of the fibre and attaching the lower end to a small, hollow but weighted, glass cylinder floating in water contained in a tube, the withdrawal of water from which causes a tension in the fibre; the amount of water withdrawn gives a measure of the tension applied. The following are some of the results obtained:—

TABLE III.

Mean breaking loads of cotton fibres.

Cotton	Breaking load (Grams)	Area of cross-section (mm.^{2}).	Tensile strength (dynes per cm.^{2}).
Punjab-American 285 F.	3·1	..	..
Punjab-American 289 F.	3·6	..	..
Punjab-American 4 F.	4·1	..	..
Sea Island	5·3	0·0013	$4·0 \times 10^9$
Texas	5·6	0·0024	$2·2 \times 10^9$
Afifi	5·9	0·0017	$3·3 \times 10^9$
Peruvian	6·4	0·0027	$2·3 \times 10^9$

It is concluded that while diameter is not a test of strength—285 F. cotton having the same diameter as Californian Egyptian but only half its strength—yet there is a significant correlation between breaking load and wall-thickness *within a given variety.* This conclusion evidently cannot hold as between different varieties, for the tensile strength of all cottons should then tend to be the same, whereas in the above table Texas cotton has only about the same breaking load as Sea Island in spite of possessing nearly twice the area of cross-section. It was also found that there was only a slight correlation between breaking load and the number of convolutions.

Various other methods have been employed for determining the breaking strength of cotton fibres. These include adaptations of an ordinary balance, a fibre being suitably mounted in a vertical position at the end of one arm and a sliding weight caused to move outwards along the other arm until the fibre breaks. This type has been used by Bowman (1) and by Matthews (4). A modification of the tensioning arrangement has been introduced by Barratt (48, 49). Instead of the

sliding weight he uses a bundle of soft iron wires suspended from the end of the balance arm with half their length inside a solenoid. The pull on the wires and therefore on the cotton fibre under test is controlled by the strength of the current passed through the solenoid. The Schopper machine is on the pendulum principle, tension on a fibre being made to lift a pendulum, the angular displacement of which measures the tension. A very ingenious though more complicated instrument is the magazine Hair Tester of Balls. This also is a pendulum instrument of a kind, but its most striking feature is the provision of various mechanical and electrical contrivances for the automatic testing of 50 fibres in succession and the automatic record of their breaking loads.

7. *Tensile elasticity.* Using the form of tester devised by himself. Barratt investigated the stress-strain relationships of various fibres. He found that the results varied greatly from fibre to fibre. The stress-strain diagram for cotton is practically a straight line, although as the load approaches the breaking point the extension tends to decrease. Barratt also measured the extent to which elastic recovering took place in a fibre on removal of the applied stress. Collins (50) investigated the time-factor for the development of equilibrium in water at 20°C., when the applied load was about one-third the breaking load. He found a period of from three days to one week was necessary, although a temporary equilibrium was often reached after about one hour. A load of this magnitude even if applied only for a few seconds caused permanent strain.

8. *Surface friction.* Adderley (53) has made some measurements of the clinging power of fibres. He made use of a slight modification of O'Neill's fibre strength apparatus, single fibres being pulled through pads of the same cotton. He found that for different fibres of a given cotton the clinging power gradually increased with the number of convolutions to a maximum, after which the clinging power decreased. With one exception the maximum occurred where the fibre under test had the same number of convolutions as the average number for the given variety. It is evident therefore that the effective fibre friction depends very largely upon the convolutions. But although various studies have been made of this feature, no general conclusions seem to be possible. Balls (8) gives some details of measurements from which he is inclined to believe that " the direction of distribution of the convolutions is related to a daily environmental effect, acting by predetermination on the convolutions through the pit-spiral patterning of the primary wall." Clegg and Harland (47) find evidence in support of this suggestion from the measurements of convolutions of eight types of cotton.

The following are some of their results :—

Cotton	Convolutions per mm.	Reversals per mm.
Sea Island	3·9	1·5
Cambodia	5·6	1·7
Afifi	5·5	1·6

They also found that the number of convolutions in any portion of a single cotton hair depends on the ratio of ribbon-width to wall-thickness, the highest mean number occurring when the ratio has the value 3·4 to 3·6. They conclude that no classification of cottons is possible on the basis of convolutions per millimetre, and it is likely that in most cottons of commercial importance the mere number of convolutions per millimetre is above the absolute minimum required for good spinning. They consider, however, that the degree of uniformity of distribution of reversals may be an important factor in spinning. Another interesting observation was that although wetting, boiling under pressure, or tensioning the cotton fibres caused a more or less profound disturbance in the convolutions, yet when the fibres were restored to their original state, the convolutions and reversals resumed their original positions approximately.

The following are some results for the mean values of convolutions and reversals in standard Indian cottons, as determined in the Technological Laboratory :—

TABLE IV.

Measurements of ribbon-width and convolutions of standard Indian cottons.

Name of cotton	Average ribbon width		Average No. of convolutions	Average No. of reversals	Average No. of convolutions per unit length		Average No. of reversals per unit length	
	Inch	Mm.			Inch	Mm.	Inch	Mm.
Dharwar No. 1	0·00067	0·017	153	24·9	139	5·5	22·6	0·89
Gadag No. 1	0·00070	0·018	137	24·6	129	5·1	26·9	1·06
Surat 1027 A.L.F.	0·00090	0·023	148	25·9	139	5·5	24·3	0·96
Punjab 4F.								
Punjab 285 F.	0·00067	0·017	161	32·2	144	5·7	29·2	1·15
Punjab 289 F.	0·00055	0·015	117	18·8	96	3·8	19·5	0 77
K. 22	0·00070	0·018	94	24·8	96	3·8	23·3	0·82
C. A.9	0·00065	0·017	150	29·0	144	5·6	27·9	1·10
J.N. 1	0 00070	0·018	100	22·2	96	3·8	19·3	0·76
Aligarh A. 19	0·00078	0·020	119	24·3	129	5·1	41·1	1·62
Coimbatore 1	0·00069	0·018	94	18·6	91	3·6	18·0	0·71
Nandyal 14	0 00074	0·019	98	20·4	86	3·4	18·5	0·73
Hagari 25	0·00077	0·020	91	21·3	84	3·3	19·5	0·77
Karunganni	0·00070	0·017	128	23·5	130	5·1	24·1	0·95
Umri Bani								
Mississippi	0·00065	0·017	175	23·9	142	5·6	22·9	0·90
Texas	0·00065	0·017	152	25·8	142	5·6	24·3	0·96

9. *Torsional elasticity.* This property has been investigated by Peirce (54) by noting the time of vibration of small aluminium rods suspended by means of the cotton fibres under investigation. He found that the values differed tremendously for different hairs from the same seed. He concluded that the mean value for a variety is, roughly, inversely proportional to the staple length. Others of his conclusions, *e.g.*, that the hair mass of all cotton fibres is the same and that their breaking loads are inversely proportional to their lengths, can hardly be said to be even approximately correct. In another investigation (55) he found the effect of humidity on torsional elasticity to be very great, the value at 100 per cent. relative humidity being less than one-sixth of its value of 0 per cent.

10. *Plasticity.* This term has been used by Peirce (56) to indicate the property of taking up a permanent set when strained as opposed to the property of recovering from or continuing to resist strains, denoted by elasticity. The measurements were made by a special magnetic torsiometer, a thread being fixed to a torsion head by which the twist is applied, and the couple measured by the deflection of a magnet, suspended from the thread, in a known magnetic field. The thread is twisted up, and the couple observed until it falls to a practically constant value and a curve of couple against time is obtained.

11. *Lustre.* The subject of lustre has recently attached a good deal of attention. As far back as 1898 Lange had concluded that the enhanced lustre conferred on cotton by mercerisation was to be ascribed to the fibres assuming a more cylindrical shape as the result of this process. This simple explanation has had a number of supporters. Herzog, for instance, states that by examining short lengths of a cotton in a mercerising solution it is possible to decide on its suitability for the production of lustre by the proportion which gives a cylindrical form. Different views, however, have been entertained, notably by Huebner and Pope and by Harrison, the former attributing the lustre to reflection from spiral ridges still remaining on the fibre after mercerisation, and the latter, although agreeing that Lange's view is substantially correct, attributed some of the effect to internal reflections. More recent work by Adderley (59), as a result of photometric measurements on 16 samples of raw cotton and on three samples of mercerised cotton, gave a striking confirmation of Lange's view; the lustre was found to be closely connected with the shape of cross-section of the fibres, those which tended to be circular in section having a higher lustre than those with flattened section. The values for lustre proved to be unconnected with the length, weight per centimetre, diameter, or convolutions of the fibre.

It may here be observed that various methods have been adopted for the measurement of lustre, most of them of a photometric type : various methods of expressing "lustre" have also been used by different observers. Thus Adderley and Oxley's original method (58, 59) was to measure the amount of light reflected at right angles to the surface with the incident light at about 60°. Zart (63), with the incident

light at an angle of 45°, measures the light reflected specularly (*i.e.* at an angle equal to the angle of incidence) and also the light reflected normally to the surface, and expresses the lustre by the difference between these. Schultz (63) makes the same measurements but expresses the lustre as the ratio of the specular reflection to the normal reflection. Barratt (62), however, using a special form of Joly's photometer, measured the percentage of light reflected at various angles of incidence and reflection ; as the angle of incidence increased, the angle of reflection was reduced by an equal amount. To give a numerical estimate of lustre he uses a similar method to that of Schultz. In their latest measurements Adderley and Oxley (60, 61) follow the superior method of Barratt, but improve on it by using a Lummer-Brodhun photometer to measure the light reflected at various angles of incidence between 0° and 60° with a constant angle of reflection (45°). They do not publish any results for cotton fibres in their first communication detailing their experiments with this photometer, but Adderley (61) has just published some interesting results for 12 cottons. He uses an expression for lustre analogous to that of Schultz, the amount of light reflected specularly at 45° being compared with that reflected at 45° with the incident light normal to the surface. His chief result is that though cottons of quite different lengths (*e.g.*, Sea Island, Egyptian. Texas) may have much the same lustre, yet in the yarn state the longer cotton gives a more lustrous yarn, a result which he attributes to greater parallelisation of fibres in the yarns from the longer fibres.

12. *Electrical conductivity.* This has been recently studied by Slater (64, 65) who measured the rate of loss of charge sustained by a gold leaf electroscope when caused to discharge through one or more cotton fibres under controlled conditions of temperature and humidity. He shows that the electrical conductivity doubles its magnitude for every 4 per cent. rise in the relative humidity (temperature constant) and for every 16° F. rise in temperature (humidity constant). The humidity effect is practically constant for all cottons, but the temperature effect is not. Two of his observations with important practical consequences may be noted. The first is that for any given value of the relative humidity there are two equilibrium values of the conductivity depending on whether the cotton has been previously exposed to an atmosphere of higher or lower humidity. The value when approaching from wetter conditions is several times greater than after approaching from drier conditions. The second point is that at values of the relative humidity of about 60 per cent. or more the conductivity is so great that the charge is conducted away so fast by the cotton hair that observation of the rate of loss of charge becomes impossible.

13. *Porosity and permeability.* These properties have been included because the practical processes of bleaching and dyeing are so closely related to them. Research on these processes yields therefore, indirectly, a contribution to our knowledge of these features, but the subject is too large to be dealt with in this short review.

14. *Physical and chemical stability.* These properties are important because the utility of cotton goods depends on their being able to withstand the action, over a wide range, of a great variety of physical, chemical, and biological agencies, such as, for example, the action of light, heat, rubbing, water, acids, alkalies, fungi and bacteria. It is well known that except as regards the action of acids, cotton is a fairly stable fibre; further, much knowledge has been accumulated as to how cottons in general, as compared with other textile fibres, behave when subjected to these agencies, but little is known as to how the various cottons compare with one another, except in a few specific directions.

III. Practical Aspects.

To discuss fully in all their practical aspects the features already described would entail a consideration of their several or joint relationships to the various processes of ginning, spinning, doubling, winding, warping, weaving, mercerising, bleaching, dyeing and finishing. This is manifestly impossible at the present stage. Moreover, as the problems in the processes after spinning are further complicated by various yarn effects, it is proposed to confine the present discussion in the main to the processes of spinning, and chiefly to the relation of the properties described above to the spinning value. The spinning value of a cotton is the most important criterion of its quality. Points observed by a cotton grader—such as amount of impurity, present length, strength and regularity of staple—are of importance because of their relation to spinning value. The fibre has to be spun and the grader relies on his estimate of these qualities as an indication of how it *will* spin. It is only such qualities as colour and lustre which are of importance in other directions.

Before proceeding further we must consider the question :—

What exactly do we mean by "spinning value" or "value for spinning purposes"? What, in other words, is our scheme of values? How may we compare any two cottons even when we know exactly how they have behaved in the spinning processes and what type of yarn they have given rise to? These questions are answered by a reference to three important limitations which determine from a practical point of view the yarn which can be spun from a given cotton. These are (1) the machinery available for converting the fibre into yarn; (2) the necessity for making such yarn as will satisfactorily withstand any subsequent processes or treatments which may be necessary; (3) the necessity which the spinner is under of making the spinning operation a remunerative one.

The differences between various types of raw cotton are such that there are limits to the degree of fineness to which in practice they can be successfully spun; moreover, economic considerations normally determine that a finer yarn shall command a higher price. Hence it follows that the limiting degree of fineness to which a fibre can be spun with greatest profit to the spinner is the governing criterion

of spinning value: at this limiting degree of fineness the yarn must have a certain minimum strength in order that it may be satisfactory in the later operations. For practical working in the Technological Laboratory a series of standards is laid down. Strength depends on the twist given in spinning; economic working depends on having few breakages during the spinning process. In testing a sample of cotton, therefore, investigation is made at three different degrees of fineness (counts) of yarn, spun with standard degrees of twist. The strengths of the resultant yarns are determined, and on the results of these, as well on observations of the behaviour of the cotton in the spinning processes, the decision is based as to the finest counts for which the given cotton is suitable.

We may now return to the problem of the relation of the physical and chemical properties to the spinning value. Our ideal would be the formulation of an equation, so that by inserting therein the appropriate ascertained values for the various properties, we should at once be able to determine, by solving the equation, the counts for which the cotton would be suitable under the standardized conditions. Thus if we represent the length of staple by 'x,' the ribbon width by 'y,' the area of cross-section by 'z,' and so on, we should have the general equation for evaluation 'C,' the finest count for which the cotton is suitable.

$$C = F\,(x, y, z, \ldots\ldots\ldots\ldots\ldots)$$

Unfortunately, little or nothing is known about this function. Reference to the foregoing pages will show that hardly any attempts have apparently been made to determine how the counts spinnable depend on the raw cotton properties. It has long been known that a long cotton gives a higher value for 'C' than a shorter cotton; that a fine fibre is superior to a coarse fibre. But normally a long fibre is also a fine one and nothing has been done to separate the effects of the two properties.

Some progress, however, has been made. If the form of the function has not been determined in terms of x, y, z, etc., something has been attempted towards simplifying it. Numerous attempts have been made, with a certain amount of success, to correlate some of the quantities x, y, z, etc., with one another. The more success is achieved in this direction, the fewer becomes the number of variables which will have to be considered, and the greater becomes the hope of an ultimate solution. The only positive statement in which a property is connected with the spinning value of a cotton, is that of Clegg and Harland (47) in their conclusion that the mere number of convolutions in most cottons of commercial importance is above the absolute minimum for good spinning. They consider, however, that the degree of uniformity of distribution of reversals may be an important factor in spinning. Balls (3), too, emphasizing the importance of uniformity, stated: "Uniformity in length must be of some importance, uniformity in diameter still more so, with uniformity in fineness, and probably uniformity in twist is the most important of all." Adderley (53) as the result of his work concludes that the important thing

is that the convolutions should interlock, and that although this is usually brought about by evenness in their distribution, it may also be brought about by fibres having varying total numbers of convolutions arranged in groups separated by unconvoluted spaces, the convolutions then being identical in the different groups.

It may perhaps be doubted whether uniformity in the distribution of convolutions has the leading role assigned to it. But further research is obviously necessary before any definite conclusions can be arrived at. The same may be said of all the properties which have been described. What is wanted above all other things is a correlation of the properties with the spinning value. Work of this nature is now being carried out in the Technological Laboratory. It is necessarily very laborious work because, owing to the irregularity of the cotton fibre in all its properties, large numbers of observations must be taken. Moreover, it is always imperative to guard against the chances of sampling error as far as possible. And when every possible precaution has been taken, there must always remain the chance that the sample has not been truly representative. These remarks apply not only to the tests of the properties of the raw cottons. They apply equally to the tests which have to be made on the spun yarn to see that it is of the standard required.

It has been previously indicated how the properties of fibres are modified by twist which binds the fibres together in the form of yarn. But the twist is never uniform in its distribution, the fibres are never equal in numbers in every section of the yarn, the fibres do not make a constant angle with the yarn axis throughout the yarn—and these unavoidable irregularities of the spinner's art and science are superadded to those of nature and the farmers who do not supply uniform raw cotton. It follows that our function for spinning value must contain a number of variables to express these spinning factors. A great deal, however, can be done to reduce their significance. Measures to this end are: (1) testing the material at each stage of the production: (2) using the same machinery for all tests: (3) recording all details about settings and adjustments of the machinery: (4) testing and controlling the physical conditions under which the tests are made: (5) careful training and supervision of the operative staff. Needless to say, scrupulous attention is given to all these points in the Technological Laboratory, where it is hoped that by making spinning tests in duplicate with the due attention to these important details, and at the same time making tests of the aforementioned properties of the raw cottons, considerable progress will be made towards solving the problem as to the relation between the properties of a raw cotton and its spinning value.

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LOWER BURMA PADDY AND ITS IMPROVEMENT.

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Out of approximately $11\frac{3}{4}$ million acres of paddy land in Burma, 9 millions are in Lower Burma, and from this area are drawn the supplies for the large rice export trade which is such a feature of the province. Efforts to improve this crop, which occupies over 90 per cent. of the cultivated area, were commenced in 1912 when an Agricultural Experiment Station was opened at Hmawbi, 30 miles north of Rangoon, and the present article is a sketch of the work carried out at this centre so far as varietal improvement is concerned: the work done on cultivation and manurial problems has been left over to be dealt with on some future occasion.

So far Hmawbi has been the only centre dealing with the Lower Burma rice crop, but two new stations are now being opened, one at Myaungmya in the Delta and the other near Moulmein, to take up the work connected with the paddies of those tracts and arrangements have been completed for both stations to commence operations this year. No consideration has been paid here to the paddy of the Arakan Division which occupies one million acres, but an experimental station was opened at Akyab two years ago and should shortly be in a position to issue improved varieties for that area.

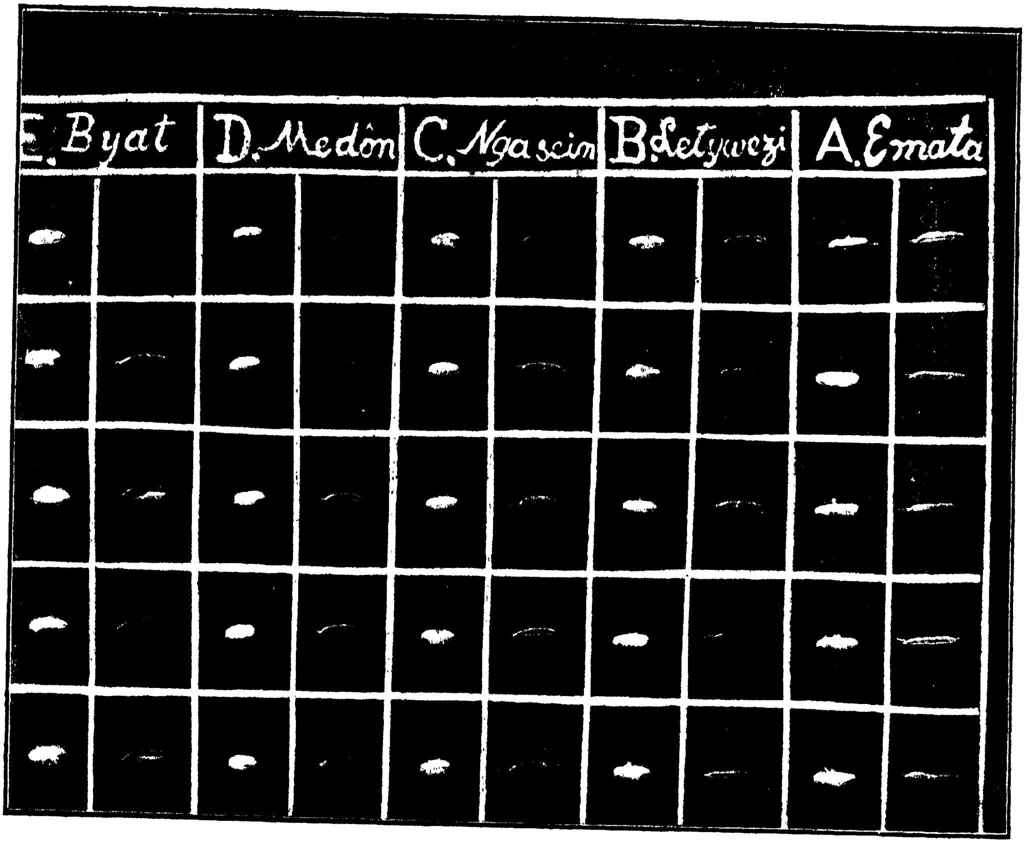
In an article in the *Agricultural Journal of India* in 1913 Mr. McKerral outlined some of the problems, and the steps it was proposed to take to improve Lower Burma paddy. This work has been carried out at the Hmawbi farm, and contact with the rice milling industry has been maintained through the Burma Chamber of Commerce to whom samples of improved seed have been sent from time to time for opinion and valuation. Reference was also made to the Imperial Institute in 1916-17 when the Indian Trade Enquiry was in progress, and samples submitted to the Special Committee enquiring into the rice trade. The report received indicated clearly the lines of improvement which should be followed with regard to Burma rice. Burma rice is a good all round rice for which there is a large and stable market, but it has faults which are best removed by improving the varieties already grown, rather than by the introduction of so-called superior varieties from other countries. The possibility of establishing varieties from other countries has not been lost sight of, however, and there is grown at Hmawbi a collection of the best rices from all the chief rice growing countries. These so far have not been very successful, and have failed to establish themselves satisfactorily under local conditions. They

have been used for crossing indigenous paddies, and although many interesting products are even now under observation, nothing of definite value has yet emerged from this line of endeavour. The work of improving the local varieties *has* produced results however, and there are several improved strains in distribution which have met with favour in the eyes of the cultivator and miller, and which are yearly spreading into new and wider areas.

TYPES AND VARIETIES OF LOWER BURMA PADDY.

One result of the large milling and export trade in rice from Burma is that the number of varieties grown is comparatively small, and bears no comparison, for example, with the innumerable varieties grown and known in Bengal: names of varieties are numerous enough but many of these are synonymous and others are applied to paddies which differ little, if at all. There is quite a number of distinct paddy varieties, however, which vary in one important respect or another, and, as some form of classification was found essential, they have been divided into five main type groups to which nearly all the Lower Burma paddies can be referred. These types are known as Emata, Letywezin, Ngasein, Midon, Byat, and can in most cases be readily distinguished by inspection, the shape of the grain being more or less outstanding. In new or doubtful cases, actual measurement of the grain is made and the type decided according to the following table of dimensional limits.

Group index	Group name	DIMENSION OF GRAIN			
		WITH HUSK		HUSKED	
		Length mm.	$\frac{\text{Length}}{\text{Breadth}}$	Length mm.	$\frac{\text{Length}}{\text{Breadth}}$
		Over	Over	Over	Over
A . .	Emata .	9·40	3·30	7·00	3·00
B . .	Letywezin .	8·40 to 9·80	2·80 to 3·30	6·00 to 7·00	2·40 to 3·00
C . .	Ngasein .	7·75 to 9·00	2·40 to 2·80	5·60 to 6·40	2·00 to 2·40
D . .	Midon . .	7·35 to 8·60	2·00 to 2·40	5·00 to 6·00	1·60 to 2·00
E	Byat . .	9·00 to ..	2·25 to 3·00	6·40 to 7·35	2·10 to 2·50 Awnless.
		.. to 11·25	2·80 to 3·40	7·30 to 8·15	2·60 to 3·00 Awned.



MAIN TYPES OF BURMA PADDY AND RICE.

PLATE XV.

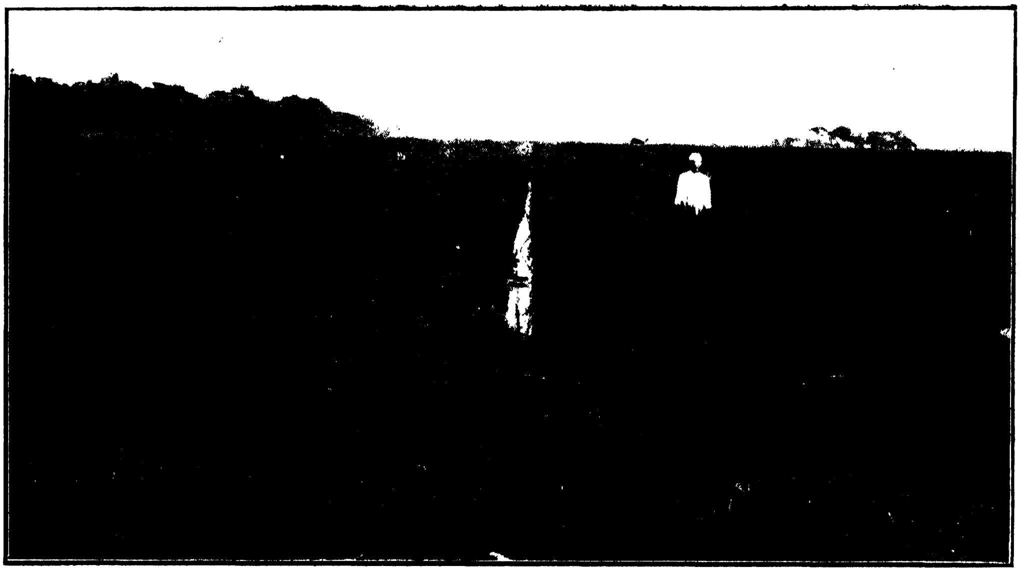


Fig. 1. A young crop of improved paddy at Hmawbi.

Fig. 2. Seed selection plots at Hmawbi.

A grain broad in proportion to its length is described by millers as a "bold" grain which suffers less breakage in milling, and this character is indicated by the $\frac{\text{Length}}{\text{Breadth}}$ factor: A and B are thin grains and the other three are "bold".

These five types have other distinguishing characters which are equally important, and a few are given below.

A. Emata has a long slender grain with the apiculus prominent and often curved. The grain is linear in shape and the kernal translucent.

B. Letywezin has a slender grain with the apiculus prominent but not curved. The kernal is slender and translucent.

C. Ngasein is a bold short medium grain with a prominent apiculus not curved. The shape is obovate and the kernal translucent, but often with abdominal white.

D. Midon is a short round bold grain with a rounded apiculus and no beak. It is usually more or less hairy and the kernal is opaque and chalky.

E. Byat is a large broad grain with a rounded apiculus, no beak and usually hairy. The kernal is opaque and chalky.

Each of the above groups is divided into early, medium, and late maturing classes, with life periods of under 150 days, 150 to 170 days, and over 170 days, respectively. There are differences in the morphological characters of the plants themselves which need not be detailed here, and it may also be noted that all the above rices are non-glutinous: glutinous rices mostly of the Emata type form a class by themselves.

These groups correspond more or less with the distinctions recognized in milling practice, although there are varieties of rices in each of these groups with special characteristics, and their own commercial names.

Faults of Burma paddy.

The faults in Burma rice which require remedying have been detailed often enough and need only be briefly summarized.

The chief of these are (1) presence of red grain among the white, (2) lack of uniformity in size of grains, (3) excessive breakage, and (4) the presence of awns.

From the miller's point of view what is required is a bold grain of regular size, free from red grain and awns, and which gives a high percentage of whole unbroken rice when milled. In a country where more than half the rice crop is exported, the grower's requirements coincide with the miller's, but in addition, the cultivator wants a hardy crop which will resist weather and insects, and produce a high yield of grain per acre.

Red grain. There are varieties of rice in which the outer coat or testa of the kernal is wholly red, and since the average white crop consists of a mixture of varieties, red grain is usually found present from about six per cent. upwards. To remove this red colour, excessive milling is necessary, and the white grain suffers

breakage in the process: the effect of this is shown by the following figures supplied by the Burma Chamber of Commerce.

(1) Outturn from 100 baskets * mixed red and white paddy milled into No. 2 quality white rice.

21·83 baskets	No. 2 white rice.
17·72 baskets	Broken rice.
10·77 baskets	Bran.

(2) 100 baskets good Delta paddy nearly all white milled into No. 2 quality white rice.

29·16 baskets	No. 2 white rice.
11·49 baskets	Broken rice.
8·5 baskets	Bran.

The mixture of red grain with the white has led here to a loss of 7·33 baskets of white rice.

Even when all the red skin has been milled off, a pink tinge is retained by most of the red rices, and although there is a limited market for red rice, white rice is the main requirement of the home and export trade. In some countries, red rice is definitely regarded as a weed and treated as such.

Uniformity. Unevenness of grain size is another serious drawback from the miller's point of view: to mill the small grains the large grains must be over-milled and needlessly broken. Here again the trouble is traceable to the mixed nature of the crop as ordinarily grown. Absolute uniformity of grain size is not attainable; because on the same plant the grains vary slightly in size at the top, middle, and bottom of the ear; but these variations are not important and the real trouble arises when grains of widely differing sizes have to be milled together.

Breakage. All rice kernals are brittle to some extent but some are much more so than others, and since whole rice is more valuable than broken rice, the grain is required to be as tough as possible to resist breakage. In testing new strains, some are found which crumble and break very badly under impact, and others which withstand the husking and polishing processes exceedingly well. Considerable importance is attached to this feature.

Awns. Awned varieties are not popular in Lower Burma with either the miller or the cultivator and they are not nearly so common as awnless varieties: they are awkward to handle, and the awns impede the milling processes.

IMPROVED VARIETIES.

While, as has already been mentioned, crossing and the introduction of exotic varieties have not been neglected, the method of improvement adopted at Hmawbi has been principally single line selection. There is a large amount of material to

* The village basket used throughout the country is a variable measure but is approximately of nine gallon capacity and contains from 48 to 51 lb. unhusked grain or paddy. The basket used by Rangoon millers is a standard 9-gallon measure with a basic weight of 46 lb.: paddy weighing more than 46 lb. is paid a poundage premium. The basket of husked rice is a fixed weight of 75 lb.

work on in the mixed paddies of the country and the results achieved so far have been distinctly encouraging : a large number of strains has been handled, as many as five hundred in a single year ; and a series of superior strains has been evolved adapted to suit varying conditions.

In Lower Burma, rice is almost entirely rain fed with little or no irrigation, and on an average holding of 25 acres the cultivator finds it necessary to sow two or often more varieties of rice, to suit high, medium, and low lying fields, respectively, although the difference in levels may only be a matter of inches.

The higher lying fields are planted with the shorter lived varieties such as Letywezin; the medium fields with varieties of Ngasein ; and the low lying fields with the longer lived Ngaseins, Midons and Byats.

There is no need for a very large number of varieties, however, and the seven which are now distributed from Hmawbi are suitable for most conditions. The following table gives their life periods and other useful data. The life periods vary slightly from year to year and place to place according to conditions, but are averaged out here and show the relative positions of the strains to one another.

Variety	Life in days	DIMENSIONS						Grains per ear	8 gallons bushel weight of paddy	Per cent. whole rice per paddy	WEIGHT OF 100 GRAINS		Husk
		PADDY			RICE								
		Lth.	Bth.	Thk.	Lth.	Bth.	Thk				Paddy	Rice	
		mm.	mm.	mm.	mm.	mm.	mm.		lb.		grm.	grm.	%
A. 16-34 .	150	9·78	2·74	2·40	7·09	2·25	1·70	231	43	45	2·88	2·21	23·3
B. 15-1 . .	160	8 90	3·05	2·19	6·48	2·63	1·95	230	47	53	2 68	2 15	19 8
C. 14-31 .	150	8·56	3·27	2·32	5 95	2·77	2·05	344	46	42	3·09	2·45	20·7
C. 19-26 .	170	8·98	3·32	2·20	6·33	2·83	2·04	177	48	52	3·00	2·38	20·8
C. 14-8 . .	180	8·38	3·30	2 20	6·07	2 78	1·91	299	48	59	2 93	2·33	20·5
C. 15-10	190	8·85	3·37	2·30	6·36	2·01	2·00	175	48	50	3·16	2·50	21·1
D. 17-88 .	170	8·40	3·77	2·47	6 27	3·32	2·13	177	49	59	3·61	2·87	20·5

Emata is practically confined to one district, Prome, with a rainfall of 45 to 50 inches, but it grows very well further south at Hmawbi with a rainfall of 95 inches. It is a fine long grain and the demand for it in Rangoon is said to be growing, especially for parboiling. There are seven local varieties of Emata, but A. 16-34 is a representative of the heaviest yielding and most robust type, which, if required, can be grown over a much bigger area than at present.

Letywezin is a type of paddy which is widely grown in Insein, Tharrawaddy, and parts of Pegu Districts, and B. 15-1 is a good example of the best type. It is not so strong in the straw as it might be, but is a good hardy plant, yields well, and mills into a good quality rice. In the localities where it is grown the rainfall is usually between 70 and 90 inches

Ngasein is grown all over Lower Burma and is the principal variety of rice exported, especially to western markets. It has a bold translucent kernal and is mostly milled into white rice. For local consumption the softer varieties of Midon are preferred, and Ngasein rice sells cheaper in the bazaar. There is a larger number of varieties of Ngasein than of any other type, and they vary widely in appearance and length of growing period. They predominate, however, in the wetter parts of the country with a rainfall of 80 to 130 inches, although they are also found in the dry zone irrigated tracts, and some of the shorter lived varieties in districts of lesser rainfall.

Four varieties of Ngasein are distributed from Hmawbi suited to different conditions. C. 15-10 is a long lived variety which does best in the Delta districts of Myaungmya, Maubin and Pyapon : it has a fine large clear kernal and produces the best rice of any of the Ngasein varieties, fetching also a better premium. The demand for it, however, is limited, since owing to its long growing period, it does not produce a full crop if the late rains are poor. Given suitable conditions it is capable of higher yields than any other variety and averaged at Hmawbi one year 75 baskets per acre over 20 acres. One grower in Hanthawaddy District reported a few years ago a yield of 93 baskets per acre from this variety. This, however, is exceptional, and, as already stated, the variety is only in limited demand since it requires specially favourable conditions for its successful growth.

C. 14-8 is a more adaptable paddy, and is more widely grown than any other variety. The growing plant is erect and compact in habit, and grows slowly in its earlier stages. This latter feature probably accounts for its being attacked in some districts by the stem borer. The yield is good, however, and the rice excellent although not so large as No. 10.

C. 19-26 is a new variety which was only distributed in any quantity for the first time last year. It meets the ever growing demand for earlier maturity, and it combines this with a yield which is higher even than No. 8 and a rice which is equally good. The plant itself is tall and handsome, with a strong straw, and grows well all over Lower Burma. Tests in all districts in the Southern Circle have given consistently high yields, and this strain is likely to become the most popular in the near future of all the varieties being distributed.

The last variety of Ngasein is C. 14-31, an older variety which matures very early but produces a rice inferior in quality to that of the others mentioned : it is comparatively soft and breaks more readily in milling. The plant grows strongly, and is much appreciated in Henzada District where it is still distributed in fair quantities, although in other districts it is now no longer recommended.

The old Midon varieties such as Bawyut were mostly awned and fairly long lived. Of recent years shorter lived varieties have been coming into favour and D. 17-88 is an example of the best type called Kamakyi. It is awnless, early matur-

ing, a good yielder, and mills into a fine white opaque rice. The distribution of this seed is confined to Delta districts and has not made as much progress as that of other varieties.

General characters of the improved paddies.

Yield. From the cultivator's point of view the chief value of a variety of paddy depends upon its yield per acre, and in the second place, on the price he can get for it compared with others. In selection work this consideration is kept very largely in view, but where the quality of the grain is very inferior even high yielding strains are discarded for those which have better all round qualities. The varieties now in distribution are all good yielders, and are better in this respect than the ordinary varieties grown by the cultivator. The following is a typical example of the difference in yield between the local and improved seed. One of the commonest Ngaseins grown by cultivators round Hmawbi farm was Ngakyauk; tested against C. 19-26 of similar life period last year, the average result of a number of plots was—

	Outturn per acre	Whole rice in milling
Ngakyauk	lb. 2,519	39 per cent.
Ngasein, C. 19-26	lb. 2,854	53 ,,

This shows an increase in yield of over 6½ baskets per acre and although much higher increases have been recorded frequently, it is fair to assume that in cultivators' hands the improved varieties yield 4 or 5 baskets per acre more than their own.

Milling qualities. Having secured a good yield the next thing is to satisfy the miller. The method of improvement followed corrects most of the faults: red grain and awns have been eliminated; and fairly even uniform grain has been produced which does not break excessively in milling. The practical effect of these improvements is indicated by the following extract of a letter from Mr. Edwards of Steel Brothers, one of the largest milling firms in Rangoon:—

"I milled 2,963 baskets of 46 lb. each into No. 2 rice obtaining 36·4 baskets of rice of 75 lb. The average milling result on No. 2 rice is about 32 baskets of rice. This shows that No. 10 paddy is a very fine milling grain due to the fact that it is pure and white." The paddy referred to was C.15-10.

Up country, where a small 15 acres seed farm run by the Agricultural Department has been distributing pure seed since 1918, a questionnaire was sent to the four small mills operating in the town near by. The replies received show that there has been a grading up in the quality of the paddy sent in for milling from the district served by the seed farm. The outturn of white rice per 100 baskets of paddy of the quality milled by these small mills used to be 40 to 41 baskets, and is now 42 to 43 baskets (75 lb.). The paddy sent in is not pure improved paddy, but is still diluted with a considerable quantity of the older varieties. These examples are typical and might be multiplied *ad lib.*

In cultivators' hands, the new varieties become mixed with the older in the transplanted fields and on the threshing floors, but the grading up process is continuous and progressive.

Premiums of from Rs. 5 to Rs. 20 per 100 baskets are paid for improved paddies by the small mills, depending upon the state of purity or admixture of the paddy as it reaches the mill.

Adaptability. Varieties of paddy which only grow well in special localities would be useless for the purpose of a general improvement of the crop throughout the country. Life period is a most important factor, and, as already mentioned, different varieties have to be selected to suit water conditions and length of the growing season. When this has been done, however, other conditions are of comparatively little importance. Ngasein 10, for example, grows well in acid soils in Lower Burma with a pH value of 6·1; in the dry zone district of Minbu under irrigation, where it is the only improved seed distributed; and in Mandalay on alkaline soils with a pH value of 8·1. There are certain broad distinctions which must be observed; Emata is practically confined to Prome District; Midon varieties are only grown extensively in Delta districts; and Byat varieties do not flourish outside the district around Moulmein. Apart from these considerations, however, the few improved varieties at present distributed from Hmawbi are suitable for the whole of Lower Burma; they have been carefully tested in every district, and have invariably done well.

Methods of seed distribution.

The central farm at Hmawbi is the original source of all improved seed in Lower Burma. In each district, there are either Government seed farms, private seed farms or both, and these, drawing their seed from Hmawbi, multiply it for local distribution. The Government seed farm is either worked by an Assistant or rented out to a tenant on terms which ensure the production of first class seed only: this seed is distributed to private seed farms, co-operative societies, and individual cultivators. Private seed farms are owned by private individuals who take their seed from the central farm, and if, after examination, their crop is sufficiently pure, it is certified, and they sell it as seed to other cultivators. There are no seedsmen in the western sense of the term, and the difficulty of maintaining seed pure in the cultivators' hands is a real one. Through carelessness, pure seed is mixed with others on the threshing floors; groundkeepers of the previous crops come up and contaminate the new seed; and in brokers' hands pure and impure paddy is mixed indiscriminately.

One way out of the difficulty is to make pure seed more readily available, and in larger quantities. With this object in view a number of new Government seed farms are being opened this year. In the Southern Circle, thirty-one of these farms of from 40 to 100 acres each, and totalling 1,500 acres, are being established through-

out the districts, and these should form new and really reliable centres from which pure seed can be obtained. A further scheme has been sanctioned whereby at the more important centres larger seed farms of 200 acres each with seed storage accommodation are being opened, to be worked by tenants under the direct supervision of a Senior Agricultural Assistant: there are 10 of these farms projected for the province of which 5 are in Lower Burma.

By these means larger and still larger supplies of improved seed will be made available in the districts with a consequent continuous grading up in the quality of the main crop. Cultivators throughout the country are coming to realize the advantages of planting better seed, and the amount of seed sent out from the Hmawbi farm has grown steadily in recent years.

	Baskets
1921	2,406
1922	3,063
1923	3,783
1924	3,972
1925	7,369
1926 (Indents)	8,350

The total recorded distribution last year, including seed farms in the Southern Circle, was 21,652 baskets. One basket is sufficient to plant out one acre. The limit of pure seed production at Hmawbi has nearly been reached, and, as already indicated, effort is being concentrated on creating larger supplies in the districts themselves, where also distribution costs are less.

As pure seed distribution continues the task of keeping it pure in the districts becomes progressively easier as the old mixed varieties are gradually replaced; but there is a long way to go before the whole crop is brought up to the standard possible, and red and uneven grains eliminated.

It is impossible to give accurate figures for the acreage at present sown with improved seed, for a considerable amount of distribution of seed takes place among the cultivators themselves of which no record is available. Estimates from the districts, however, show that there is an area of 100,000 acres planted with almost pure seed, and a greater area with seed which has been mixed to a greater or lesser extent with local varieties.

Small mills, of which there is a large and increasing number in country districts, invariably pay premiums for even small quantities of pure paddy, but for paddy bought and mixed by travelling brokers for the big mills in Rangoon, Bassein, etc., it is more difficult to get full value for a good sample. Big mills maintain that they cannot afford to pay premiums for lots of less than 10,000 baskets, but even here there is a growing differentiation between the prices paid for ordinary and improved paddies. Efforts are being made to encourage the joint sale of their improved produce by co-operative societies direct to the big mills, cutting out the brokers entirely, and a successful beginning has been made with the societies around Hmawbi

farm where a joint sale was carried out this year to a Rangoon mill with complete satisfaction to all concerned.

With such a large area under rice in the province, the present area sown with pure seed is a comparatively small proportion of the whole, but the progress of improvement which was at first slow is gradually gaining strength ; district staffs are being strengthened and new seed farms are being opened in all directions ; millers and cultivators are growing in their appreciation of the new and improved varieties being placed at their command.

Nothing encourages the production of improved paddy so much as the certainty that a higher price will be paid for it, and buyers of paddy can do much to encourage improvement in this way.

A great deal of steady progress has already been made towards the general improvement of the Lower Burma paddy crop, and although much more still remains to be done, the measures now being undertaken to increase the supply of pure seed should result in greatly accelerated progress in the future. The search for new and still better varieties of paddy is being actively continued and many problems connected with the cultivation of the crop still remain to be solved ; but given time, there appears no reason why the whole of the Lower Burma crop should not reach a higher standard than it at present attains.

THE IMPROVEMENT OF THE COTTON PLANT.*

BY

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Introduction. The first thing necessary is a definition of what is meant, in this paper, by the word "improvement," when applied to the cotton plant. Any inherent modification of the plant, whether morphological or physiological, which enables the field crop of that plant to compete commercially more successfully with the field crops of other plants, may be considered as an improvement. Such a definition does not cover any cultural improvements. A disease-resisting plant would be included as an improvement, but special methods of growing the crop which enable the crop to resist disease more successfully would not be included, although the special methods may involve as a result a modification of plant form. The problems of improvement in this limited genetic sense will be chiefly considered in this paper, though it will not be possible entirely to exclude other aspects. They will also be chiefly considered from the point of view of the practical cotton breeder who has not unlimited time or staff, and who is economic in his outlook.

Methods of improvement. In cotton the ideal which is attempted and seldom attained is an early and heavy yield per acre of good quality lint. Harland has stressed the importance of analysing the factors which make up yield. His unit factor is the weight of lint per seed. Other factors being equal, a cotton which has the greater weight of lint per seed gives, of course, the heavier yield. Following Harland, other factors for yield can be deduced. These are:—

Weight of lint per seed (or lint index).
Number of seeds per lock.
Number of locks per boll.
Number of bolls per plant.
Percentage of bolls to flowers.
Number of flowers per plant.
Number of plants per acre.

A similar analysis of the factors which make for early maturing can be made, *viz.* :—

Period of germination.
Period from germination to formation of first bud primordium.

*Paper read at the Indian Science Congress, Bombay, 1926.

Suitable root growth and leaf growth to prevent early shedding.
Formation of first bud at an early node on main stem.
Time taken from the laying down of one node to the next on main stem.
Time from one node to next along the sympodium.
Time of flower maturation from bud mother cell.
Time of boll maturation from flower.

Many of these physiological characters have proved to be remarkably constant within one variety, and also from season to season (2 and 3). The time taken from the laying down of one node to the next, for example, is constant, and does not depend on the temperature at the time (3). The period during which an internode of a sympodium elongates is also constant, though very considerable variations in length may be obtained in this fixed elongation period (3). In breeding for an early maturing variety therefore the conception of the production of bolls as an almost mechanical process should be helpful and should give immediate information on the inherent possibilities of a variety. In a comparison of certain *desi* varieties, for example, a plant which bears its sympodia low down on its main stem should be earlier than one which bears them higher up. Again, Punjab-American which bears all its bolls at the very ends of its sympodia may be called constitutionally early, but culturally late.

Only a beginning has been made in the determination of those physical properties which make for high quality. " Cling ", a quality which is looked for by Alexandria graders, has been shown to depend on the convolutions of the single hair (4).

Adderley presumes that this factor has a spinning value. The same author also has shown that lustre depends on the shape of the cross-section of the cotton hair (5).

Work is also in progress on the mercerising of cotton (6).

A good quality lint is supposed to mercerise better than a poorer quality lint. It appears that the difference in this case proves to be connected with the structure of the cuticle of the fibre. But the reasons for these physical differences in the fibre are still unknown. Mrs. Howard said, two years ago before this Congress, that " quality in produce is generally associated with definite localities." This is part of the secret, but the variety grown must also be important. Sakel cotton, in addition to its yield, also loses part of its quality when grown out of its environment. The skilful grader can actually recognize Sakel grown in different parts of the delta of Egypt. Deductions from observations on the relations between daily elongation in Sakel and temperature led Dr. McKenzie Taylor and the author to the conclusion that Sakel grew best with a certain daily range of temperature at a particular period of its growth. In the locality where Sakel gave the best yield and best quality, this range of temperature was found to occur more frequently during the period of maximum growth than in other localities where Sakel did not do so well. Outside Egypt in localities where Sakel had been tried and failed, this range did not occur. This work may never be completed, but further indications were obtained that other varieties required a different temperature range for their most satisfactory growth,

PLATE XVI.

WRINKLED LEAF.

PLATE XVII.

BAHMIA COTTON.

These observations lead to the conclusion that for quality, each locality must produce its own local form, adapted to its own environment. *Prima facie* it should be possible to attain as high standard in quality and yield in one locality as in another; the problem is to find the correct unit species for each locality.

Practical methods of improvement. These will be considered under three heads :—

(1) Selection.
(2) Acclimatizatior
(3) Hybridization

(1) *Selection.* The normal procedure in pure line work is based on Johannsen's work with beans. A plant with desirable features is selected from a mixed crop, the flowers on selected plants from its progeny are self-pollinated, and from the self-bred seed so obtained next year's pure lines are obtained and so on. In due course, theoretically, a strain pure for all major characters is obtained. East and Jones, however, in their book "Inbreeding and Outbreeding" (page 130) say that it is not until after about three generations of self-fertilization that extreme types begin to appear. Such is what actually happens with cotton. Two examples from the author's experience may be given. A wrinkled leaf dwarf—probably very similar to Harland's dwarf rogue—suddenly turned up in a pure crop of Egyptian cotton,—and a cotton, typical of a peculiar cotton which was cultivated in Egypt about 45 years ago, and known as "Bahmia" cotton [described by Dudgeon (7)], appeared in a propagation plot of a new type at Giza.

The wrinkled leaf type was a simple recessive to the normal type of cotton as in Harland's case; the Bahmia type is also almost certainly a simple recessive though this has not yet been worked out.

Kearney (8) recently has also shown the probability of hereditable variations in Pima which was apparently an entirely uniform variety. Selection in cotton becomes therefore somewhat more complicated than it seems and is made still more difficult and tedious by the precautions necessary against the natural cross-fertilization which takes place in the field.

It must be emphasized that all selection work must confine itself to a certain district. It is hopeless to try to select on one experimental farm for a district in which the climatic conditions or the soil differ from the conditions on the experimental farm. The growing of pure lines should be done in the neighbourhood of the district for which the new strains are intended so that they are grown under the conditions in which they will eventually be propagated. The laboratory records and routine work can, however, be done at a central laboratory. In selection with cotton, the normal procedure at the start is to go amongst the crop at the time the bolls are opening, and pick out those plants which by their actual performance in the field show themselves superior to other plants. The number of bolls on the plant indicate its yielding power, the number of bolls open indicates its early maturity, and the quality of its lint and its length can be determined later in the laboratory,

when a further selection is made. Discrimination in choice must be exercised, as the position of the plant in the field may exert a preponderating influence. A plant on the edge of the field, or at a spacing greater than the normal, may give an entirely false impression of its capabilities. Even when conditions are normal, the yield of a single plant cannot give more than the vaguest idea of the value of its progeny in field crop for yield. It is not till a new strain has reached some bulk that it is possible to institute yield comparisons by chequer plotting. Chequer plotting on a scale suitable for cotton is very wasteful of seed, as the seed from chequer plots cannot be used for further propagation.

Balls, with his flowering curves, pushed back a stage the point where yield comparisons could be instituted ; but even there, there is a waste of seed, and a scatter of plots is just as necessary.

In selecting for yield therefore it must be realized that the selector relies partly on luck and largely on experienced speculation for his improved type. The problem is to eliminate this element of luck as early as possible ; thereby eliminating numbers of types which would otherwise have to be continued, with the consequent increase in the routine records, observations, etc., which are required.

If we refer back to Harland's analysis, we find that although the unit factor in yield is the weight of lint per seed, this may not be the determining factor for final yield. Other things being equal, it is so ; but it is seldom that it can be expected that other things will be equal. The number of seeds per lock, or the number of locks per boll, or the number of bolls per plant, may be the determining factor.

It is a pessimistic but probably correct view, that never will it be possible to obtain numerical data on a single cotton plant (assumedly homozygous) which will indicate its performance in field crop.

The next stage is the pure line family obtained from the single plant. Here the ground is safer, for there should be approximately a hundred plants on which to make observations. These plants also can be grown at definite uniform spacings so that one cause of variation is partly overcome. Detailed observations on all of the hundred cannot be carried out, but from each family a number of plants can be selected as typical of the family (The family is assumed to be pure. Impure families are naturally discarded, though single plants may be selected to start other pure line families.)

The plant averages, however, can be easily obtained for such characters as lint length, seed weight, and lint index, and from these the family averages can be calculated ; these averages are used in comparisons between different pure lines.

When dealing with large numbers, the numbers to be taken for these averages have to be carefully considered.

Normally, not less than 20-25 plants would be considered safe and a satisfactory correlation co-efficient in the following year can then be obtained with the progeny families. In the third year this correlation co-efficient can be applied as a test of purity. The correlation co-efficient between the parent average and the progeny

family average for a true pure line should approximate to zero. The method has been used in Egypt satisfactorily and is also applied to other crops, but it requires considerable labour, as so many plants have to be dealt with. Another problem of selection work is the reduction in numbers necessary from one year to the next. Only a certain number of pure line families can be grown in the space available and there is a limit to the labour available to deal with them. It is generally found that more plants pass the tests applied than there is room for in the field. A final sowing selection has to be made, and this selection is frequently difficult, as there is little choice. All the plants are desirable, or they would not have survived so far. It has been found that pedigree records, showing the performance in previous years of the strain concerned, are of the greatest use in this final selection.

The laboratory tests of purity to be applied must be chosen almost solely from the labour point of view, for it is important that all the tests chosen are applied to all the plants which come under selection. Lint length, lint index and G. O. T., seed weight, and plant yield are characters which can be measured simply and rapidly and can all be done in the laboratory during the winter season ; the length of boll maturation period, and comparative percentage shedding can be obtained from the routine records of selfing, but tests which require numerous routine measurements during the actual growth of the plant such as leaf factor or petal size are quite impossible if large numbers have to be dealt with ; though leaf factor, for example, would be undoubtedly of the greatest use as an index of vegetative purity. In practice it is found that vegetative characters must be judged largely by eye. A criterion of what might be called " selectability " is the root development. Where the vegetative habit of a plant varies so much as in cotton, it is probable that the root development also varies greatly. The importance of root development is obvious and may be the determining factor in the suitability of a type of cotton for a certain locality. This has already been shown to be the fact under certain conditions in the United Provinces (10). But so far no method has been devised, nor does it seem within the bounds of possibility that root development can be used as a test of the selectability of a single plant. If the plant's performance is satisfactory, it must be presumed that its root machinery is efficient. This emphasizes the point referred to earlier that selections should be made on the spot.

To enlarge a little, and with more particular reference to quality, Alexandria graders say they can distinguish easily between Kafr el Zayat Sakel and Zifta or Damanhour Sakel. In the Punjab, Sailana district *desi* is supposed to be of a finer quality than *desi* of the same variety from other districts. But it is of no use to sow Kafr el Zayat seed in the Zifta district or the Damanhour district, nor presumably is as fine a quality obtained from Sailana seed in other districts. This may be a problem of root development which shows itself in the plant's temperature reactions. Kafr el Zayat plants have not that root development which fits them for the Zifta district. The only solution is to select in the actual district. There appears no reason why selection in the district should not produce the Kafr el Zayat quality on

the Zifta root. At the moment the tendency is for centralized cotton breeding stations. If root development is to be considered as one of the factors in cotton improvement—and it must be so considered—district sub-stations for actual selection must be employed.

Acclimatization. Little need be said about acclimatization. It is a favourite form of cotton eugenics, and has been tried and has almost consistently failed, for many years. In analysing the causes of failure, the reasons are at once apparent; the experimenter was not sufficiently patient, and expected too much. If acclimatization is considered as accelerated evolution, it is realized at once that the process must be slow. Five years or ten years cannot be expected to give results. Even twenty years may not be long enough to accomplish what might be accomplished in nature in 200 years. Further it must not be expected that an unchanged form will grow as suitably in a new environment. Changes must be expected and the problem confronting the selector is to see that as many of the original characters are retained as possible. Actual experience shows that improvement can be expected. In acclimatization work, pure line selection must naturally be employed, as an additional means of acceleration.

Hybridization. Artificial hybridization is looked upon as the main weapon in the plant breeder's armoury, but for cotton it is doubtful whether at present it is so powerful as for some other crops. Thadani (11) differentiates the characters of cotton into two classes, those which tend to increase the intrinsic value of the crop and those which serve as a distinguishing mark to keep the strain pure. In the genetics of cotton, however, the basic problem is to determine which are unit factor characters.

Certain characters of the seed are shown by Thadani to depend on a single factor as does also the amount of lint per seed. He cautions plant breeders, however, against applying generally the results of particular crosses, and this caution is necessary in the latter case. Kearney (12), in determining the inheritance of 39 characters, only found three which were fairly clear cases of single factor characters, namely, petal spot, anther colour, and midlock furrow index, none of which appears to be of particular agricultural importance.

Turning to factors of more direct economic importance, it has been found that length of lint (12), length of vegetative period and type of branching (13) and, particularly, yield are governed by so many factors that no experimenter has yet arrived at any unit difference which could be ascribed to a single genetic factor.

There is no doubt that these characteristics are heritable but the operation of the laws which govern their inheritance is still obscure. It is possibly significant that no commercial variety at present grown in any bulk has originated as a deliberate synthetic product by a plant breeder. Even in the case of the cross between Kumpta and *neglectum rosea* mentioned by Kottur (14) it was only after careful selection that the combination of the characters of the parents was obtained in pure strain. Artificial hybridization then can only be considered as a means of obtaining desirable

combinations in the progeny but there is no certainty. The F_2 families, in fact, must be looked on in the same light as a mixed crop, from which desirable plants can be selected. The advantage of artificial hybridization is that the mixture is more concentrated, and so selection is simplified. Bailey at the 1924 meeting of the Imperial Botanical Conference strongly recommended that artificial hybridization should *be* left severely alone by a practical cotton breeder until he had done his best with the crop at his disposal and also obtained pure lines whose purity he could guarantee. This advice is undoubtedly sound if results of economic importance are to be obtained.

It is difficult to assign any reason for the incorrigibility of cotton. The large number of chromosomes may account for it Cotton is on a par with man in this respect. Yet it is found that a single factor in Harland's Dwarf rogue or in the Egyptian Wrinkled leaf will change the whole body of the plant, main stem, leaves, flowers and anthers Another single factor only affects the petal spot. The red coloration of the sap is due to a single factor, but length of lint may be due to about one factor per millimetre.

An exhaustive and theoretical study of single factor characters is therefore an essential before certainty can be obtained in the production of new types of cotton by hybridization Kearney (12) and Dunlavy (15) have tabulated numerous correlation co efficients between vegetative and seed and lint characters. But it cannot be stated definitely that the characters chosen were single factor characters It seems probable that the single factor in cotton frequently may affect more than one organ of the plant ; and till work has been done on this aspect of the problem, correlation co efficients between measureable characters must lose a portion of their value.

SUMMARY.

Summarizing, it will be noted that the main problem in the improvement of the cotton plant is to put theory into practice. A method of selection by pure line work is briefly described and can be usefully supplemented by acclimatization work The importance of the root system and the necessity for the production of local unit species is emphasized. Artificial hybridization at the present stage of knowledge does not introduce any certainty of improvement along directed lines, but combined with selection probably increases the chance of obtaining desirable combinations of characters.

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SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director:* MR. J. T. EDWARDS (ON LEAVE); *Secretary for Publications:* MR. S. K. SEN).]

VI. THE PIROPLASMOSES OF CATTLE IN INDIA.

A PRELIMINARY NOTE.

BY

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PIROPLASMS are minute protozoan parasites that invade the red blood corpuscles of animals, and rather closely resemble the malarial parasites of man. The name " piroplasm " is, however, used as a comprehensive term to designate a number of specifically, or even generically, different organisms, the term " piroplasmosis" being applied to diseases caused by these parasites.

In other countries no less than seven alleged species of " piroplasm " (Brumpt, 1920) have been described in cattle, although in some cases the distinctions that have been made are probably not well founded. A very well-defined distinction exists, however, which permits of these organisms being divided into two main generic groups—*Babesia* (=*Piroplasma*) and *Theileria*.

At the Imperial Institute of Veterinary Research, Muktesar, systematic examination of blood smears and also *post-mortem* examinations have been carried out continuously during the last three years, and a total of three to four thousand blood smears have thus been examined during each year. From these examinations and also from the examination of a number of blood smears made from cattle in other districts, it is evident that in India " piroplasmosis" of cattle is widespread, the " piroplasms " discovered so far being of two kinds only, one representative of each of the two generic groups indicated above.[1] It is permissible to add to this

[1] The definite diagnosis of the two species of " piroplasm " found in cattle at Muktesar and the view that they are the only species yet detected at the Institute, have both been arrived at by the Director of the Institute.

number a third parasite described by Sheather (1919) as a malarial parasite in the blood of buffaloes.

In a paper read before the Indian Science Congress at its meeting in 1924, reference was made to the two most important of these parasites, and the methods that may be used to restrict or eliminate the diseases caused by them were described. It is proposed to give in this paper a further brief description of these parasites, which would entail a certain amount of recapitulation of the facts referred to in the previous paper.

Babesia bigeminum is the largest of the bovine "piroplasms" and in their typical form they are found inside the red blood corpuscles resembling two pears joined at their tapering extremities, with their bodies set at a somewhat acute angle (Plate XVIII, fig. 1). This form is commonly found in slight infections, particularly of the "carrier" type. It would appear that infection with this parasite is so widespread in India that probably in most localities cattle become infected as young calves, at which age they possess a high degree of resistance and recover readily, and are subsequently immune by virtue of being "carriers" of the parasite in a latent state of activity for the rest of their lives. These parasites, however, are also the cause of an acute and severe disease in cattle, known as tropical redwater. This disease occurs when infection is transmitted at a later and highly susceptible stage in the life of cattle, such as when adult cattle are imported into India from a country where "piroplasms" do not exist. The disease also results when the immunity, obtained by cattle as young calves, is broken down, such as is liable to occur through the effects of intercurrent disease conditions due to, for example, rinderpest or exposure to adverse conditions. At the height of this disease, as many as 75 per cent. of the red blood corpuscles may be invaded, and the parasites then assume many varied forms, although the typical form may still also be present in small numbers. A very common form is a single parasite within the corpuscles, round or oval in shape, with a deeply staining structure representing the bezel. Many irregular elongated and ovoid forms are usually also present which vary considerably in size, and not infrequently a few parasites are seen to be quite free and outside the corpuscles.

Although under natural conditions the disease is transmitted through the agency of ticks, it can be readily set up also by the injection of blood containing the parasites, into a susceptible bovine animal. In this case a sharp rise in temperature occurs between the 6th and the 10th day after the injection, and sometimes a day or two later. Frequently, after the fever has been in progress for a very short time the urine of the animal becomes coloured red from the presence of destroyed blood corpuscles excreted by the kidneys, and it is from this symptom that the disease receives its name of "redwater." On account of the widespread infection of Indian cattle with this "piroplasm," accidents occasionally occur in this way during the so-called "serum-simultaneous" method of inoculation of cattle against rinderpest, where a small quantity of blood from an animal suffering from rinderpest has to be

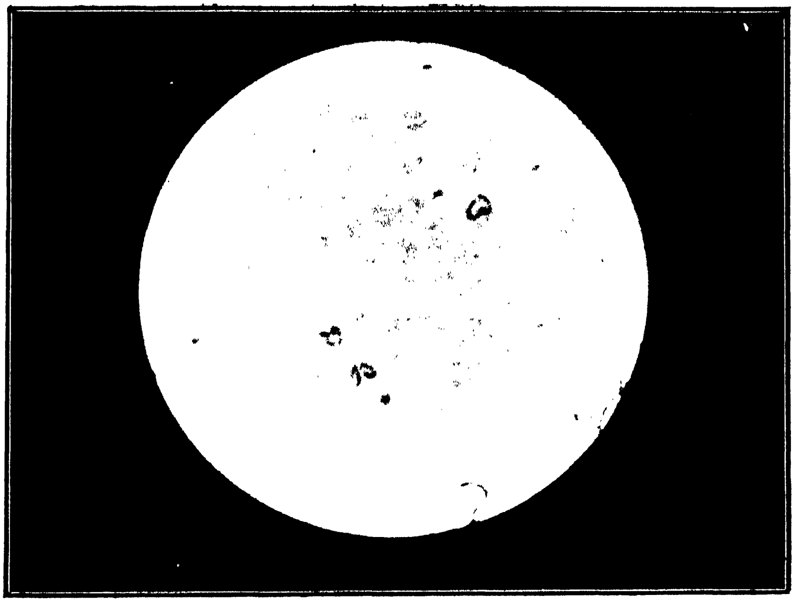

Fig. 1. *Babesia bigeminum.* 800.

Fig. 2. Koch's Blue Bodies. × 1860.

used, and this complication has to be feared most of all in adult imported cattle. Sometimes, however, animals die suddenly from the effects of invasion by this parasite, without passing red-tinged urine, and in these cases occasionally no " piroplasm " can be detected in blood smears made in the ordinary way from the peripheral blood. This is due to the very rapid multiplication of the parasite within the minute blood vessels of certain organs, notably the kidneys and the brain, and a diagnosis can then only be based upon the nature of the temperature curve, or upon examination of smears made from these organs.

It is fortunate that the disease caused by this form of " piroplasm " can usually be successfully treated by the prompt use of *trypanblau*, which appears to exert a specific action upon the parasites.[1]

Theileria mutans is a very much smaller parasite than *B. bigeminum*, and occurs within the red blood corpuscles both as short rod or comma-shaped structures and also as round or oval " ring " forms, while very occasionally bodies resembling a minute Maltese cross may also be seen. This parasite has a very wide distribution throughout the warmer countries of the world and appears to be almost universally present in Indian cattle; at least, at Muktesar it is difficult to obtain cattle free from it. In the majority of animals, however, the parasites may not be detected until continued daily examination of the blood is made. *T. mutans* is usually considered to be harmless, and under certain conditions considerable numbers of them may be encountered in the blood, although the affected cattle usually exhibit no ill effects. The form of the parasite, as it occurs within the blood corpuscles, is quite indistinguishable from another " piroplasm "—the formidable *Theileria parva* which is the cause of the disease known as East Coast Fever, and infection with this parasite has been responsible for enormous mortality in cattle in Africa. The distinguishing feature between the two parasites has been held hitherto to be the presence of earlier developmental forms in the case of *T. parva*, which have the appearance of comparatively large cell-like structures, known as " Koch's blue bodies " (Plate XVIII, fig. 2). Until quite recently, it was believed that no such bodies occurred in the life history of *T. mutans*.

In certain countries, notably in Egypt and the Trans-Caucasus, what appeared to be a third species of parasite, belonging to the genus *Theileria*, has been described as *Piroplasma annulatum* (Dschunkowsky, 1904; Carpano, 1915). This " piroplasm " was found to be responsible for a certain relatively small mortality in cattle, and " Koch's blue bodies " were found in animals dead of the affection; yet the disease showe certain marked differences to East Coast Fever of East and South Africa. Quite recently an interpretation of the recorded facts that has received much support is as follows. Brumpt (1923) has shown that when blood from an animal harbouring the chronic " carrier " type of infection with *T.*

[1] It is of considerable interest that *Babesia bovis* (*B. divergens*; Brumpt, 1922), the other " piroplasm " incriminated with the causation of bovine piroplasmosis, has not been detected in India. The parasite, although it resembles *B. bigeminum* in certain aspects, yet differs in the very important act that it is not acted upon by *trypanblau*.

mutans, is injected into cattle in a country known to be entirely free from the "piroplasmoses" (*e.g.*, France), a fatal disease may result in which "Koch's blue bodies" are present. There is a very good reason to believe, therefore, and this hypothesis has been strongly held by the Director of the Imperial Institute of Veterinary Research, Muktesar, that the creation of the species *annulatum* is not justified, inasmuch as the disease described as due to such a parasite, represents in all probability only an acute and fatal infection with *T. mutans*. Further, it may even be stated that *T. mutans* and *T. parva* are such closely related species of "piroplasm," differing only in their degree of pathogenicity in cattle, that *T. parva* is probably only a particularly virulent strain or variant of the almost universally present *T. mutans*.

During the systematic examination of cattle at Muktesar, the possibility (which has been suggested both by the Director of the Institute and also by Sir Arnold Theiler, Director of Veterinary Education and Research in South Africa) of the presence in India of "piroplasms" of the *annulatum* type was borne in mind, and on 12th June 1922, at *post-mortem* examination of a hill bull that had died suddenly and unexpectedly, lesions resembling those of the disease described in Egypt were found, and no difficulty was experienced in demonstrating the presence of a very heavy infection of the blood with *Theileria*, together with large numbers of "Koch's blue bodies" in the cells of various organs. During the summer of the same year, six cases of this kind were detected, and in the following year (1923) a further three were found. During the winter of 1923-24 a visit to the Muktesar Institute was made by Sir Arnold Theiler, who is responsible for the original discovery in Africa both of *T. parva* (1904) and of *T. mutans* (1906). At that time he examined smears from the cases found at Muktesar and declared that the parasites belonged to the genus *Theileria*.

In some publications upon the subject (*e.g.*, Brumpt, 1920), mention is made of the previous detection of *Theileria* infections of cattle in India, with the presence of "Koch's blue bodies." Correspondence has recently been entered into with Montgomery, who is credited with the publication of this fact. It would appear that in 1911 a smear alleged to have been made from the spleen of a bovine animal in India was sent to an assistant of his in East Africa by a Veterinary Assistant in Bombay, and upon examination Montgomery confirmed the presence in it of "Koch's blue bodies." It is, apparently, from a verbal mention of this incident that the occurrence of this parasite in India has been recorded in the publications referred to. Although ordinarily, therefore, widespread distribution of the chronic harmless type occurs in India, under certain circumstances, which are at present not well understood, mortality in cattle may occur from "piroplasms" of the genus *Theileria*.

Plasmodium bubalis, described by Sheather (1919) in the blood of a buffalo, has only been encountered on two occasions at Muktesar, during the last three years, although since the first discovery and previous to 1922 it has not infrequently been

detected. This number in all probability, therefore, gives a quite erroneous impression of the incidence of infection. As far as it is known at present, the parasite is not responsible for any marked ill-effects in the animal affected, although the number of blood examinations of buffaloes during the period has not been very large. In both the cases referred to, the animals had died, and the carcases had been disposed of before examination of the films was made. In both cases also, the parasites were extremely rare in the smears examined and no opportunity has yet occurred for further study of the infection.

THE COTTON GROWING PROBLEMS OF THE BLACK SOILS IN INDIA.*

BY

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AND

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On the black soils of the Peninsula, the cotton crop is mostly raised on the natural rainfall. The yield therefore is at the mercy of the monsoon. Irrigation is undeveloped although in some tracts subterranean supplies exist which, if utilized, would markedly increase the yield per acre. The conditions on these soils therefore are very different from those of the alluvium in North-West India where a very large portion of the cotton crop depends on canal irrigation.

Cotton does best in most parts of the black soil tract if the rainfall is *below* the average and also well distributed. Under these conditions, growth in the early stages is rapid, the size of the mature plant is well above the normal and the bolls mature early. Further, there is little disease and boll shedding is insignificant. Heavy rainfall, on the other hand, is very harmful to the crop. Growth is slow, the plants are stunted, the yield is low and the bolls open late. In such seasons the various pests take a heavy toll. Heavy rainfall on the black soils therefore introduces a limiting factor in growth which appears to be an excessive development of soil colloids. These interfere with aeration and percolation and profoundly influence the flora and chemistry of the soil as well as the root-development of the cotton plant.

The most pressing problem in cotton growing on the black soil of India is the discovery of the best means of dealing with these soil colloids so that the grower rather than the monsoon can take command. At present, the grower is at the mercy of the rainfall and the yield is a matter of chance. What is wanted is to furnish the cultivator with some weapon by means of which the position can be partly or entirely reversed. The first step in this undertaking is to improve the surface drainage of each row of cotton plants so that local water-logging can be

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* Paper read at the Indian Science Congress, Bombay, 1926.

prevented. At Surat, Mann and his staff have made a very promising beginning in this direction. Cotton is grown on broad ridges instead of on the flat. Growth and root-development are thereby stimulated and the yield of lint is markedly increased. There is, however, an obvious limit to the improvement possible by this means as colloids develop even when the soil is thrown into ridges. The adverse factor can be attacked in at least two directions, firstly by means of sub-soil drainage and secondly by the use of substances which tend to put the colloids out of action and promote flocculation. Allan's experiments[1] at Nagpur show that sub-soil drainage on heavy black soils has a beneficial effect on percolation and on the growth of cotton and other crops, but whether the improvement is great enough in the eyes of the cultivator to justify the trouble and expense of the method is a question which cannot be answered at the moment. Further work is desirable in this direction in localities like Broach which produce superior types of cotton.

The addition to the soil of substances like safflower cake and various chemicals is perhaps the easiest and most promising direction of dealing with colloids. Safflower cake is a valuable manure from two points of view. It acts on the soil in two ways: (1) indirectly by putting the colloids out of action and (2) directly by providing nitrogen in a readily available form. Further, it is a local product. It seems probable that *karanj* cake (*Pongamia glabra*) has a similar action on the soil. At the Institute of Plant Industry, Indore, an application of *karanj* cake at the rate of five maunds (400 lb.) to the acre increased the yield of *kapas* by more than 25 per cent. Much more work is needed on the secondary effect of manures of this class in promoting percolation in black soils during the rains. The indirect effect of these cakes and of various chemicals on these soils offers a wide field of useful work for both the physicist and the chemist. It is one which has been almost entirely neglected in India.

There is another direction in which the study of colloids is likely to be of considerable value on black soils, namely, in preserving the life of irrigation wells. If more wells could be provided in these tracts the door would be opened to the successful cultivation of superior types of cotton and large yields would be possible. There is, however, one great difficulty. When wells in the trap area are worked beyond the rate of natural recovery experience shows that the yield of water rapidly falls off and the wells often die. This result appears to be due in many cases to the uncovering of the inter-trappean layers through which these wells are fed. If the water-bearing layers are frequently exposed to the air, as is bound to happen every time the well is emptied, all the conditions are set up for the rapid formation of soil colloids from the partially disintegrated trap and the cracks through which the water enters the well slowly become sealed by these gummy substances. The well then gradually ceases to function although the supply in the adjoining under-

[1] These experiments were published in *Bulletin 85 of the Pusa Research Institute* in 1919.

ground reservoir may be adequate. The precise causes of the gradual death of overworked wells in the trap area is a matter which urgently calls for detailed study. In this work at least three sciences—physics, chemistry and geology—can be utilized. Once the scientific principles of the subject have been fully worked out it will not be difficult to formulate a set of simple rules for the correct use of wells on these soils and thus safeguard the capital involved in their construction.

Soil colloids are also likely to prove an important factor in the study of diseases of cotton on black soils. It is suggested that such problems as cotton wilt, the attacks of parasites like the various boll worms as well as the shedding of bolls should include the consideration of adverse soil factors such as the excessive development of soil colloids as well as the root-development of the crop and the zones of root activity during the whole period of growth.

Once the development of colloids can be controlled the door will be open to a number of further improvements such as the increase in the nitrogen supply by fixation from the atmosphere and by the addition to the soil of various forms of nitrifiable organic matter.

Simultaneously with the study of soil conditions the type of cotton grown also needs investigation. Some portions of the black soil tracts are very suitable for the growth of indigenous types of good staple like *Malvi* and *Bani*, the cultivation of which has fallen off considerably of late years. The chief plant breeding problem at the moment is to restore and if possible to improve these valuable types. One great difficulty, however, has to be overcome. This is the high ginning percentage of a short stapled variety known as *Roseum* which is rapidly invading the *Malvi* and *Bani* tracts. To check this and to restore the quality of the fibre it is essential to produce more efficient types of *Malvi* and *Bani* which can successfully compete with *Roseum*.

SELECTED ARTICLE

THE ORGANIZATION OF SCIENTIFIC RESEARCH THROUGHOUT THE EMPIRE.*

BY

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(*Concluded from Agricultural Journal of India*, Vol. XXI, Pt. III.)

IMPERIAL BUREAUX.

As I have said, special Imperial Bureaux were set up in London before the financial depression, which followed the war, induced the Dominions to halt. So far as they have gone, it seems fair to conclude that they promise to justify the cost of their permanent maintenance and to indicate the desirability of re-considering other subjects. We might consider in order those devoted respectively to entomology, mycology and minerals.

ENTOMOLOGY.

Anyone who has lived in a tropical country will be able to appreciate, as a consequence of painful personal experience, the importance as well as the magnitude of measures intended to stamp out noxious pests or to encourage friendly insects. Among the special branches of science of economic value to an Empire with large possessions within and near the tropical belt, I should regard entomology as perhaps first in importance. A few illustrations of each sort should be sufficient to illustrate the damage as well as the benefactions due to insects.

It is only because of their want of information about the devastation caused by insects that those responsible for the administration of agricultural and horticultural countries limit their expenditure on entomological services. In America, where these services are most developed, we are able to obtain figures which show that the cost of employing entomologists is negligible when compared with the losses that might be avoided. The losses in 1921 due to the cotton boll weevil in the United States amounted to some 40 million sterling, and in the same year in Egypt

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* Address to the Royal Society of Arts. Reprinted from the *Jour. Royal Soc. of Arts*. No. 3809.

the pink boll-worm caused damage to the cotton crop estimated at a total of about 10 millions. One could multiply examples of this sort.*

The blood-sucking insects known as tsetse-flies have almost depopulated large areas in Africa, and are extending their ravages, some as transmission agents for sleeping sickness and others as the carriers of the deadly disease of nagana among cattle. The epidemic in Uganda some 20 years ago killed off about ten per cent. of the population ; but the cattle-killing is even more devastating though less spectacular ; for the people who escape sleeping sickness are driven out of the country for want of the cattle on which they depend for a living.

The mosquito, as the host of the malarial parasite, is responsible directly for a large fraction of the 4-5 million deaths annually returned as due to "fevers" in India alone, without regard to the amount by which the lives of many millions more are shortened and those of still larger numbers made less efficient and more liable to succumb to other diseases.

On the other hand, insects carefully cultivated may be of immense economic value. The product, for example, of the lac insect exported from India annually amounts to over 7 million sterling. The silkworm in Japan alone produces material of the annual value of over 60 millions.

It is important, too, to consider the magnitude and difficulty of dealing with an insect scourge. We speak loosely of the tsetse fly and the mosquito, but there are dozens of distinct species included under both of these vague names. Most are irritating, many deadly dangerous ; but, in adopting curative and preventive measures against noxious insects, the entomologist has to discriminate with precision between species which to the general public pass under comprehensive terms, but which in structure, in habits, in usefulness and in destructive activities differ as much as a man differs from a monkey. Even more meticulous precision is necessary in encouraging the development of beneficial insects, for in this matter discrimination is necessary not between one species and another only, but between varieties and races differing from one another as the greyhound differs from the sealyham. And in the class of insects the number of distinct species can be described only as colossal. The work of identification in entomology has become so voluminous that several specialists for this work alone are now necessary, and the correct identification of species is but a preliminary step in the much larger and more difficult problem of studying their life habits and then of adopting safe and suitable measures for their development or their destruction. Many of the most serious instances of widespread damage to agriculture have arisen from species which have been accidentally introduced into a new country without their natural parasites, so that they have been able to increase to an abnormal extent in their new environ-

* In the *55th Ann. Rep. Ent. Soc. Ontario* for 1924 (pp. 30-46) C. L. Metcalf estimates the total annual damage done by insects to staple crops in America alone at £165,000,000. In spite of the commendable development of entomological services in America, it is probably difficult to obtain any precise figure, and precision matters little ; for to obtain a contrast between the cost of the entomologist and that of the insect a few millions either way does not affect the ratio appreciably.

ment. It required very little imagination to realize the kind and quantity of work necessary to discover and repair such mistakes.

If we estimated the importance of economic entomology only by the damage done by pests to crops, it would be obvious that the cost of any research operations so far contemplated by any civilized Government is negligible. But the damage done to cultivated crops is not the only or even the greatest economic loss due to insects which prey on the forests, on wild plants of value and on all animals, including man, both by direct attack and as carriers of disease.

Most civilized countries employ entomologists to some extent, but I am concerned just now only with the kind of machinery devised for correlating activities through the Empire. The Imperial Bureau of Entomology at South Kensington was the only one of its kind that was brought into being before the Great War. It arose from the Entomological Research Committee which was founded in 1909 to stimulate investigation in connection with the injurious insects of Tropical Africa, especially those that transmit disease. In 1913 it was decided to extend the organization to deal with economic entomology throughout the Empire, and it is now supported financially by annual contributions from 15 Governments of the Dominions and Colonies, in addition to £1,000 from the Imperial Government, giving it a total revenue of £11,800. The extent to which this Bureau is used by official Entomologists in the Dominions and Colonies is shown sufficiently by taking one only among its many activities, namely, the identification of insects, which requires comparative work in a comprehensive collection like that of the Natural History Museum. During the past five years an annual average of 50,000 insects have been examined by the staff of the Bureau.

The other activities of the Bureau include the production of a Review of Applied Entomology, in which during the past five years abstracts of articles to the number of 2,309 annually have been issued for the benefit of independent and isolated workers who have not, naturally, access to more than a fraction of the 1,200 periodicals in which the articles appeared in various languages. Another obviously useful function of the Bureau is the distribution to universities, hospitals and Government institutions of identified specimens of species known to be of economic importance. In all about 27,300 insects were thus distributed between 1920 and 1925. One of the most recent activities of the Bureau is the distribution to various parts of the Empire of parasites likely to be destructive to insect pests. The importance of this work must be obvious to everyone ; the difficulties and dangers that attend it are fully appreciated only by the biologist.

One can form an imperfect appreciation of the kind of organization required for work of this kind, organization and administrative capacity at the head, tactful tactics in curtailing its sphere of influence over those who are jealous, often properly so, of their own state establishments, and conscientious devotion to work involving a mass of mechanical, often dull, routine which can only be of real value if carried on with meticulous precision and rigid faithfulness. To Dr. Guy Marshall

and his faithful colleagues the Empire owes a real debt, and the best way to pay the debt is to increase their work. That the work of the Bureau is appreciated is shown by the number of Governments that support it. That the degree of appreciation varies is shown by the range of annual contributions from £25 to £1,000, but in no case does the amount devoted to this object form an appreciable fraction of the direct financial importance of economic entomology. There is room still for expansion in various directions, without fear of overlapping those activities that can be most efficiently performed locally.

I have dealt with entomology at some length, because to most people insects are familiar as friends and foes, and no subject could better illustrate the importance of co-operation between workers in different parts of an Empire covering such a large share of the tropical zone. But it is only because of our ignorance of damage done by other forms of life that we fail to recognize equally the importance of similar action in other branches of biological control.

MYCOLOGY.

Mycology is a subject that possibly comes next to entomology in the width and intensity of its bearing on the raw materials of an Empire largely dependent on vegetable products, whether cultivated in fields or wild in forests. Diseases of plants caused by fungi form losses of unknown, but certainly great, dimensions in the temperate as well as in the tropical zones, and plants are not the only victims of parasitic fungi.

There are nearly 100 official mycologists in overseas parts of the Empire, most of them attached to Government Departments of Agriculture. Generally they have excellent laboratories and research stations, but this development of science accessory to agriculture and forestry is relatively young and these workers consequently have limited opportunities for access to authentic specimens of parasites, with insufficient literature recording the results obtained elsewhere. The necessity for co-operation is obvious, and fortunately as the result of discussion at the Imperial War Conference in 1918, the Colonial Office was enabled to initiate proposals for the formation of an Imperial Bureau of Mycology on lines similar to those which had proved already to be successful for entomology. The originators of the scheme were fortunate in finding the right type of specialist ready and able to organize the work ; for Dr. E. J. Butler, as a successful " plant doctor " in India and Malaya, had acquired the necessary experience for visualising the difficulties which isolated plant pathologists had to face ; he was relieved of official duties by his Government to commence the work of Director of the new organization in 1920.

The Bureau of Mycology is financed by contributions from the Dominions, Colonies and Protectorates amounting annually to £5,500, no grant being made by the Home Department. The programme which the Bureau aims to fulfil includes the work of identifying injurious fungi and diseases referred by workers in over-

seas parts of the Empire, in addition to the dissemination of information through its Monthly Review; but for want of trained workers it has not been possible so far to undertake all that is desirable and would obviously be useful in helping investigators with identification problems that are refractory or insoluble in areas far away from authoritative reference collections.

Thus the chief work done by the Bureau during the first five years of its existence has been that of a clearing house of information for the benefit of overseas workers. The current volume of the *Review of Mycology* contains some 1,500 abstracts from 450 periodicals published in various languages, and the regular issue of this monthly *Review* has formed the main function of the Bureau so far. But information in other ways is supplied to working specialists, copies of papers and reprints of summaries are lent freely, and overseas Governments are kept in touch with the progress of legislation intended to assist in the suppression of plant diseases.

The development of the information part of the Bureau has paved the way conveniently for more direct assistance in the essential work of identifying obscure and little known parasites; for the work which has been done in recent years on areas previously untouched now forms a substantial foundation for advance.

For the immediate purposes of our present discussion the limit set by the Bureau on its own functions is as important as the outline of what it actually undertakes. It definitely avoids research as such on plant diseases, for the Director realizes, from his own field experience, that this can be done effectually only by local workers, either in Britain or overseas. The enthusiasm of scientific workers incurs the constant temptation to go beyond their last, with the consequent liability of trespass.

The work done by central institutions like the Bureaux of Mycology and Entomology is available to more than official workers in the overseas parts of the Empire. The more enlightened associations connected with the planting industries know their practical worth, such, for example, as the Indian Tea Association, the Rubber Growers' Association and the Colonial Sugar Refining Company of Australia.

MINERALS.

Another bye-product of war enthusiasm was the Bureau designed to assist the mineral development of the Empire. It arose from the resolutions of the Imperial War Congress in 1917, and was granted its charter on the 12th June, 1919, having for its main functions (1) collecting statistics of mineral production, exports and imports, both for the Empire and foreign countries, for it was considered important to know the possibilities of the latter as competitors and customers; (2) accumulating information as to the occurrences of minerals and the uses to which they could be put; (3) disseminating this information to all who would profit by it; (4) collecting and publishing details of the mining laws and regulations in force in different parts of the Empire, and advising the Governments in the enactment or amendment of such laws and regulations; (5) promoting co-operation between firms interested in

mining and metallurgy, and between them and research workers in the universities and public institutions as well as with overseas Governments.

In the early days of the Bureau it was financed by the British Government, but from 1920 onwards it was to be supported jointly by the United Kingdom, the Dominions, India and the Colonies. In that year £10,000 was supplied by the first-named, and about £9,400 by the remainder. In addition £1,000 was paid by the National Federation of Iron and Steel Manufacturers for a special publication on iron-ores. That year represented the high-water mark of the finance of the Bureau. In the face of the commercial depression which followed and the rival claims of the Imperial Institute, the Dominions and Colonies reduced their contributions, whilst the British Government limited theirs to the total received from the other Governments, so that the income of the Bureau was ultimately reduced to little more than £10,000.

After being threatened with extermination it was amalgamated last July with the reconstituted Imperial Institute, in the hope that thereby some unnecessary overlapping of effort might be prevented and money might be saved.

Trades' Research Associations.

The Trades' Research Associations are supported by firms engaged in certain technical industries, such as the textile industries, rubber and tyre manufacture, cocoa and confectionery, non-ferrous metals, refractories and electrical industries. Altogether 25 of these have been launched and all but two are still active. To the general student of affairs organizations of this sort must always be of interest, especially in a country where there has been a tendency for competing firms to guard from the public and from one another, through shyness or the supposed commercial advantages of their special methods, the intimate and domestic details of their operations.

Some detached and disinterested precipitant, as a chemist would say, was required to bring competitors into active co-operation; for evidently even recognized improvements must sometimes be of doubtful value when their adoption necessitates the scrapping of capital alteady invested in plant and machinery suitable for established methods. Although the firms individually could not undertake the research work necessary for definite advances in manufacture, a scheme that threatened to cut across the marked individuality of British manufacturers was naturally regarded at first with caution and occasionally with suspicion. The initiation was thus taken by the new Department of Scientific and Industrial Research.

In practically every case the scientific verdict on the work leaves no room for doubt as to the potential value of Research Associations to the industries with which they are associated. But while the industries for the most part are ready enough to admit in the abstract the need for and value of scientific research into

their processes and methods of manufacture, they almost without exception plead that they cannot afford, in the present bad state of trade, to raise unaided the funds necessary to establish their Research Associations on a stable foundation. Yet, in comparison with the value of the trade in which the industries are engaged, the sums required for the continuance of the work of existing Research Associations are astonishingly small. A few examples will make this clear.

The British Cotton Research Association spends about £45,000 a year on its work, whilst the annual value of the raw cotton imported and retained for manufacture is between 50 and 60 million sterling. In other words, another farthing added to every pound sterling paid for their raw material represents the cost to the manufacturers of investigations recognized by them as commercially valuable. Similarly, a penny added to every pound paid for imported wool and a half-penny to every pound's worth of rubber represent the amounts respectively spent by the two corresponding associations. Neither the Government nor the manufacturers have hitherto fully appreciated the fact that so far as production costs are concerned, the maintenance of research workers is still a negligible item. It is interesting therefore to see a Committee of the Privy Council finding it easy to justify its existence. In their last report just issued one finds them referring to the fact that it is intended this year to spend £40 million on the erection of small houses to meet some of the recognized shortage, and one finds from the returns of the Advisory Council, given in an appendix to the same report, that they have spent £11,940 on building research during the past year : that is to say, for a third of a farthing added to each pound spent on the small houses alone, information is being obtained which will ensure that the money is better spent. Three years ago an Act was passed to raise funds to provide better amenities for coal-miners. The levy of one penny a ton on coal raised produces a million sterling annually. What would our technical industries be like if we had spent a million a year on industrial research from the commencement of the new century ?

Empire Cotton Growing Corporation.

The Empire Cotton Growing Corporation, which received its charter in 1920, might be regarded as a super Research Association. The formation of this body deserves more than a passing mention ; for whilst its scope is analogous to that of the various Trade Research Associations, it is on an exceptionally large scale, covering activities in all parts of the Empire. Thus, the Corporation differs from the other Research Associations in being imperial rather than merely, or mainly, national. It has unusual powers in its relations to the manufacturing industry, which, because of its size and financial value, is conspicuous in its national importance.

Before the War the value of cotton goods exported amounted to £127 millions out of a total of £411 millions for manufactured goods of all sorts ; and these figures

only partially express the value of the industry; for one-eighth only of the raw cotton imported went out again in the form of manufactured articles. The capital invested in the industry amounts to some £500 million and the whole of it depends for its existence on raw material obtained from outside, mainly foreign sources.

When it is realized that cotton growing countries are rapidly extending their own mill capacity, and have the power to assist their industries by restricting the export of the essential raw materials the danger of relying on foreign sources for it becomes obvious, even alarming. The effect of the American Civil War should have been a sufficient warning of the risks to which the industry is exposed, but subsequent prosperity with a gradually rising curve to represent output and value effectually lulled all fears till the Great War came and stirred our cotton magnates afresh. The financial stresses which followed the war reinforced the conclusions of the Birchenough Committee; for the price of American cotton showed no sign of adjusting itself to the reduced purchasing power of Europe. The outturn of the cotton fields fell off for various accessory reasons, whilst mills in the United States increased their demand for the raw material, and even indicated the possibility of America itself becoming a serious competitor for outside supplies, including the fine Egyptian varieties.

To the commercial enterprise and mechanical skill of the people of Lancashire we were originally indebted for turning to account certain natural advantages of their country in climate and fuel supplies. To the public spirit and co-operative disposition of their leaders also we are now indebted for this new and remarkable effort to make the Empire self-contained and independent of outside sources. It is true that the great effort now being made by this Corporation would not be possible without State aid, financial and legislative; it is nevertheless the direct product of Lancashire enterprise, for the Corporation is the lineal descendent of the British Cotton Growing Association which was formed in 1902. The powers and resources of the Association, however, did not permit its influence to be felt much beyond the African fields, and something wider was wanted—an association with resources sufficient to combine the agricultural with the manufacturing problems, and sufficient to afford to wait many years for the results necessary to ensure stability for the industry.

The new Corporation derives its income partly from a capital contribution of nearly a million granted by Government and partly from a levy of six pence per standard bale on all cotton purchased by spinners in this country. This levy, in accordance with the wishes of the trade, has been made obligatory on all spinners by an Act of Parliament which received Royal Assent in July 1923.

The progress of the Corporation can be estimated by the reports and papers which are issued quarterly in the *Empire Cotton Growing Review*, which began in January 1924. From this it will be seen that, in addition to the staff at Millbank House, which is the headquarters, there are various specialists in South Africa Rhodesia, Swaziland, Nyasaland, Sudan, Uganda, Queensland and the West Indies,

The Corporation is in touch with the official agricultural services in India, the Dominions and Colonies; it finances research work at Cambridge, Manchester, Rothamsted and the Imperial College; it is developing a scheme of training post-graduate students to recruit its overseas staff and its latest enterprise is the establishment of a central research station in Trinidad for the purpose of investigating the cotton plant in all phases of its growth and under conditions rigorously controlled.

The only comment that I feel safe in making on this remarkable enterprise is that Lancashire does not intend, and is not likely to be forced, to give way to competitors elsewhere; and if it ever changes its religion on fiscal questions it will have merited protection by showing a readiness to fight on fair trade lines without artificial help.

INDIAN COTTON COMMITTEE.

It is necessary to mention that the Corporation here has been closely followed by a similar organization, but with a more limited range of action, in India. Following the investigations of a Special Committee which reported early in 1919, the Indian Central Cotton Committee was constituted by resolution of Government on the 31st March 1921, and its efforts have been supported by subsequent legislation. The Cotton Cess Act, which was passed in February 1922, gives the Committee the benefit for the first three years of four pence on every bale of cotton consumed in Indian mills or exported, and two pence per bale thereafter. The Committee, with an assured income on a large scale, is planning research work in agriculture as well as in manufacturing problems, and its efforts will be supplemented by the Cotton Transport Act of 1923, which is intended to limit the evils due to mixing of good and less valuable strains in the course of cross-country traffic.

DOMINIONS.

I have already referred to the fact that, after the institution of the Department of Scientific and Industrial Research in this country, corresponding organizations were set up in the Dominions and India. With the close of the war these underwent changes in constitution and functions which are worth careful study.

The idea originated in Australia and, although arrangements were devised to meet demands made on the Commonwealth during the war, the Australian National Research Council began its first session in August 1921. The Commonwealth Institute of Science and Industry had been, however, organized a year before, and its constitution was adopted by an Act passed in September 1920. The Act lays down that the Director shall, as far as possible, co-operate with the existing State organizations in the co-ordination of scientific investigation, with a view to the prevention of unnecessary overlapping and the utilization of facilities and staffs

available in the States. Powers are given for arrangements to be made for co-operation with State Government Departments, universities, technical schools, educational authorities, and scientific societies, not only as regards the conduct of actual research, but also with a view to advancing the teaching of science, the training of investigators in pure and applied science and of technical experts and the training and education of craftsmen and skilled artisans.

The progress of the Institute has been restricted for want of funds. The total vote in 1922-23 was £20,907 ; but on the 30th May 1925 the Prime Minister called a conference to discuss the future, and a scheme for expansion was adopted involving an estimated annual expenditure of £100,000. The provincial patriotism in Australia, which persists as a consequence of the original settlement in independent and well separated States, makes co-operative action slow, but is an insurance against over-centralization. The operations of the Commonwealth Institute are not likely therefore to displace the research work being conducted in the universities and other State institutions.

In Canada the Honorary Advisory Council for Scientific and Industrial Research was formally constituted by an Act which was passed in August 1917. Subsequent annual reports show that the Council considered it essential that a National Research Institute should be built to supplement its work of assisting research in various established institutions. On the 19th July 1924 fuller powers were granted by an Act of Parliament which declared that " the duties of the Council shall include the charge of all matters affecting science and industrial research in Canada which may be assigned to it, and also the duty of advising the Committee of the Privy Council on Scientific and Industrial Research on questions of scientific and technological methods affecting the expansion of Canadian industries or the utilization of the natural resources of Canada."

In South Africa the Industries Advisory Board was established on the 2nd May, 1917, and arrangements were made to ensure co-operation with the adjoining South African Protectorates and Rhodesia. The duties of the Board were transferred to the Department of Mines and Industries in 1923, and the functions of this Department now resemble those of the Research Department in this country in providing for co-ordination within the Union and co-operation with institutions overseas.

The Department of Industries and Commerce in New Zealand undertook in 1917 similar functions, necessarily on a smaller scale, for the Dominion.

So far as administrative machinery goes, it is obvious that all the Dominions have systematically reviewed the various facilities and necessities for research; the machinery has also been adopted to suit the special conditions of each country. The only feature on which one feels tempted to comment is that arising out of the Canadian proposal to build a special Institute for the Dominion. In this country the Research Department confines its executive action to the direct control of specialized institutions, such, for example, as the National Physical Laboratory, the Fuel Research Board, the Building Research Station at Actom and the Geological

Survey, which last, as a strange British tradition, has always fortunately been treated as a separate national institution in each Dominion except Australia. Even these are controlled by Boards so constituted of scientific men that parts of the work and related researches already carried on in independent institutions are intelligently supported.

There is an obvious danger in the activities of central, compound, or general institutes of research. Research workers have always more ideas in their heads than they can readily develop and complete in practice. They always hope to find time to work out problems for which they feel an inspiration, and they naturally hesitate to pass them on to others. This influence of normal human nature is relatively harmless in a specialized institute; for when a deferred problem is tackled, it is worked out thoroughly. But the temptation to reserve a "claim" is stronger in a general institute, and its resultant dangers are more serious; for its governing body represents ordinarily the financial interests which support the institute, instead of being composed of critical specialists. This, I think, has been the disadvantage under which the Imperial Institute has suffered. The most useful service that a general institute of the sort can perform is to pass on problems to specialists, putting the enquirer and the scientific worker into direct touch, contenting itself by becoming a clearing house for information, especially in the direction of knowing who's who and what each is doing in the scientific and industrial world. The success of the Department of Scientific and Industrial Research has been due to a faithful recognition of this principle, and its perpetual observance from the start was ensured by the creation of the Advisory Council in 1915.

INDIA.

India, which was provided with a suitable administrative organization before the war and whilst it lasted, is the one conspicuous example of subsequent disintegration. In India the necessity of co-ordinating official activities in scientific research was recognized by Sir Denzil Ibbetson as long ago as 1903, when a Board of the principal officers of the scientific departments was formed. One of them was appointed as Secretary, and fortunately, it was the distinguished botanist on whom His Royal Highness conferred the Albert Medal last July and who is present to-night to accept our recognition of his Birdwood Memorial Lecture.

Following the expansion of scientific services devoted to the investigation of raw materials, the Government of India in 1916 appointed a Commission to advise on measures necessary for developing the manufacturing industries and the Commission recommended large increases of the scientific services based on an extension of technological education, with a scheme for the co-ordination of private as well as official work, both imperial and provincial. Soon after the Commission reported, the Government of India Act of 1919 came into force, and, with it, the failure to recognize the fundamental distinction between advisory and executive functions.

Evidently, in advisory work the requisite degree of thoroughness can be obtained only by employing specialists, and these cannot be maintained in sufficient variety by each of the nine provinces, with their problems of unlike nature. For executive functions, promptness and a familiarity with the peculiar local conditions are the dominating requisites. The policy of provincialising industrial research of all sorts has, however, been adopted without discrimination, and most of the proposals of the Industrial Commission must accordingly remain fruitless, until India discovers that no modern country can face the commercial competition of peace time, or defend itself in war by merely repeating maxims of political theory. India is now being doped with fiscal protection instead of being prepared by industrial training to develop its own natural resources in a healthy way. If the present course is followed, India will become still more dependent on outside sources for manufactured articles, which naturally are continually changing in form and increasing in variety for civil as well as for military activities.

The country will be forced to go outside for its requirements in some forms of food, as it is doing already on a large scale for sugar. Natural indigo, exported in large quantities, has already been displaced by the chemical product of European science. What science has done in Europe it should be able to do still better in a country with natural climatic advantages, but not by processes which are translated unmodified from other countries. Improvements in agriculture and processes of manufacture must be based on research in India itself under Indian conditions, not on reports made on samples sent to the Imperial Institute. Unless research workers are specialists they are dangerous, and the requisite number and variety of specialists, with their equipment, can be maintained only by the co-operation of all provinces. Recent movements in India have been in the opposite direction, and the result must necessarily be a loss of natural economic advantages; so far as raw materials are concerned, the place hitherto occupied by India will be usurped by Central Africa, and for manufactured goods she will become more and more dependent on Japan, Europe and America. In industrial problems, India is not now being helped to work out her own salvation, but is being allowed to prepare for an entirely different destiny.

UNITED STATES.

In spite of the length of this address, the omission to mention many movements and institutions must be obvious to everyone who has been conversant with the developments of recent years. To resist the temptation to follow up many side issues has been very difficult, but I may be pardoned if I refer very briefly in conclusion to what is being done in America; it shows how modest is our scale of operations even now.

The National Research Council in the United States is entirely a co-ordination agency, and its financial resources are devoted mainly to the maintenance of its

own administrative machinery. During 1921-22 the Council estimated that the equivalent of about £6,000,000 was spent on research in applied science, about one-third of the money being obtained from the National and State Governments. The area affected is of course more compact and uniform than the British Empire, but the degree of authority and activity of each of the States justifies some regard being paid to the relative amounts which are devoted to the work.

The data of most instructive value are those relating to the specialized Bureaux at Washington, for they approximately correspond to the ideal set out originally for the Imperial Bureaux that we have established in London. Under the Department of Agriculture there are seven Bureaux of the sort, and for purposes of comparison, or rather contrast, we might take that devoted to Entomology for which this year the equivalent of just half-a-million sterling has been voted, against our £12,000. The expenditure of Washington does not include the sums spent by the individual States, some of which maintain services comparable in size to those of our Dominions. The Bureau of Entomology is by no means the largest; but we need not consider the others as our Treasury officials would blush; nor should we comment on where the money comes from or our friends at Washington might do more than blush.

Conclusion.

I think our members will agree that at last we have completed in skeleton form at least, a scheme for a systematic organization, which, if developed faithfully, will be suitable for imperial as well as for national needs. The course of evolution has been slow and has been accompanied by many side steps; indeed, has been typically British. The organism has now acquired the essential structure of its species, but we have yet to shed, or, I hope, to absorb and more fully utilize, such vestigial organs, for example, as the Imperial Institute, that have served an ornamental and, in their own times, a useful purpose, in spite of the fact that like all such superseded vestiges, they have caused some inconvenience to the general body. We have in this country now laid substantial foundations in the Department of Scientific and Industrial Research, and we have made plans for an Imperial superstructure, but the plans of a house, no matter how well drawn, offer insufficient shelter for the householder; there is still much to be done by way of building and still more by way of furnishing, all of which requires money and building materials in the form of research workers, which our universities, if adequately supported, should be able to supply.

NOTES

CALCIUM CYANAMIDE

THE problem of finding efficient and inexpensive fertilizers, whether organic or inorganic, is one that is ever engaging the attention of the Departments of Agriculture, the tea and coffee planting industries, as well as everyone interested in agriculture, whether directly or indirectly, throughout the length and breadth of India. It will therefore be of interest to all who are concerned in the agricultural future of this country to know that this very valuable nitrogenous fertilizer, calcium cyanamide ($CaCN_2$), is now available in India almost everywhere where fertilizers are sold.

It may seem superfluous perhaps to say here that the nitrogen in calcium cyanamide is derived from the air by the process commonly known as "nitrogen fixation" and that it is not a by-product of any existing industry. Therefore, with 30,000 tons of nitrogen in the air over every acre of sea and land throughout the globe, the supply may be said to be inexhaustible.

Hitherto, the use of calcium cyanamide in India has been confined almost exclusively to the tea and coffee planting industries, where it is better known perhaps by the name of "Nitrolim," the trade name of the cyanamide produced by a well known Swedish plant. Last year, however, certain commercial arrangements were made in London whereby the surplus output of every producing plant in Europe became generally available to the British Isles, the whole of Europe and every country in the East.

Certain important advantages have arisen out of these commercial arrangements which may be briefly enumerated as follows :—

(1) The price has been greatly reduced and stabilized.

(2) The percentage of nitrogen has been brought up to a uniformly high standard.

(3) Some important improvements have been made in its general composition.

Examining these three points in detail :—

(1) Calcium cyanamide can be bought to-day in Calcutta, Madras or Bombay @ Rs. 187 per ton of 2,200 lb. (1,000 kilos). This price is a striking comparison to those obtaining a few years ago when it is believed that as much as Rs. 290 was being quoted for calcium cyanamide in Calcutta.

(2) The nitrogen in cyanamide is now of a uniform 19 per cent. standard. Thus @ Rs. 187 per ton, the unit of nitrogen costs Rs. 9-13-0. This price, combined with its other valuable properties, notably that of improving the tilth of the soil, makes cyanamide of peculiar interest in India ; for, generally speaking, it is improvement in physical condition which is so badly needed in most soils in India.

(3) The most important improvement in its manufacture is the addition of the requisite amount of mineral oil, whereby the former rather dusty nature of cyanamide has been overcome, rendering it as easy to use as any other finely ground material.

Up to this year comparatively few experiments have been conducted with cyanamide in India. Here and there isolated trials have been carried out, but, probably owing to the fact that it was not generally on the market and that the European sources of supply were not easy of access, there has been no great incentive to put cyanamide to exhaustive tests.

The very valuable experiments and researches which have been pursued continuously over the past seven or eight years by the Madras Agricultural Department, must not be lost sight of. The results of this important work were made known in a paper which was read at the Indian Science Congress in January 1923 by Dr. Roland Norris who, in conjunction with Mr. Viswanath, had carried out this research work at Coimbatore. This paper is published as a Memoir of the Department of Agriculture in India entitled "The Decomposition of Calcium Cyanamide in South Indian Soils." The conclusions to which Dr. Roland Norris came are of much interest.

Now that calcium cyanamide is generally available in India at an economical price, the position as regards its possible usefulness as a form of added nitrogen is entirely different. The Madras Agricultural Department are continuing their work with cyanamide this year, and a series of experiments will be conducted at Pusa and by the Agricultural Departments of every province in India, in connection with those crops in which they are severally interested. Trials are being made too by private individuals in Assam, South India, Bihar and in the Punjab. The results of all these experiments and trials will be of considerable interest.

Generally speaking as regards India, the time is yet remote when chemical fertilizers will be used universally all over her millions of acres of cultivation. Much work has yet to be done in the direction of improved methods of cultivation before the lands in many places are fit for the use of inorganic fertilizers. The Departments of Agriculture are making steady progress in this direction, and when the character of the Indian cultivating classes as a whole is taken into consideration, the work which has been achieved in the past 20 years is little short of marvellous.

There are, however, to-day many hundreds of thousands of acres where the addition of an inorganic fertilizer, suited to the particular crop and soil, is undoubtedly a very profitable proposition to the ryot, and he has not been slow to see this in

certain districts, where its application has become a certain and steady addition to his income.

It may therefore be left safely to the Departments of Agriculture concerned, who have the full confidence of the ryots, to demonstrate to them the advantage of the use of such a manure as cyanamide, wherever they find that it will be of distinct benefit to the grower of the crop concerned to apply it. [R. G. MUNN.]

DESTRUCTIVE INSECTS AND PESTS ACT.

In exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor General in Council is pleased to direct that the following further amendments shall be made in the rules published with the notification of the Government of India in the Department of Revenue and Agriculture, No. 580-240, dated the 26th June, 1922, as amended by Notification No. 1062-240, dated the 18th December, 1922, and the schedule appended thereto, namely :—

1. In the proviso to rule 4 of the said Rules for the words " immunity from disease " the words " freedom from disease " shall be substituted.
2. In column 1 of the schedule for the figures " 4 (ii)," the figure and letter " 4 (*b*) " shall be substituted.
3. In columns 2 and 3 of that part of the schedule relating to certificates required by clause (*b*) of rule 4, after the entry relating to New Zealand the following entries shall be inserted, namely :—

" *Holland.*—The Department of Agriculture.

Germany.—The Departments of Agriculture.

**Other Countries.*—The Ministry or Department of Agriculture of the country concerned ; and the following footnote shall be added, with reference to the last of these three entries, namely :—

* When a Customs officer receives a certificate required by clause (*b*) of rule 4 from any country not specified by name in the part of the schedule which relates to such certificate, he shall, after passing the consignment, forward the certificate to the Government of India, Education, Health and Lands Department, for information.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE ROYAL COMMISSION ON AGRICULTURE IN INDIA.

The following are the names of the Members of the Royal Commission on Agriculture in India which was announced by His Excellency Lord Reading in the last winter session of the Legislative Assembly :—

Marquess of Linlithgow, Chairman ; Mr. Hubert Calvert ; Professor Nogendra Nath Gangulee ; Dr. Lodhi Karim Hyder ; Mr. Balkrishna Sitaram Kamat ; His Excellency Sir Henry Stavely Lawrence ; Sir James Mackenna ; Sir Thomas Middleton ; The Hon. Raja Srikrishna Chandra Gajapati Narayan Deo of Parlakimedi ; and Rai Bahadur Sir Ganga Ram.

The Commission is generally to examine and report on the present conditions of agriculture and rural economy in British India and to make recommendations for the improvement of agriculture and the promotion of the welfare and prosperity of the rural population. The Commission is particularly to investigate : firstly, the measures now being taken for the promotion of agricultural and veterinary research, experiment, demonstration and education, for the compilation of agricultural statistics, for the introduction of new or better crops and for improvement in agricultural practice, dairy farming and the breeding of stock ; secondly, the existing methods of transport and marketing of agricultural produce and stock ; thirdly, the methods by which agricultural operations are financed and credit afforded to agriculturists ; fourthly, the main factors affecting rural prosperity and the welfare of the agricultural population.

It will not be within the scope of the Commission's duties to make recommendations regarding the existing systems of landownership and tenancy or of the assessment of land revenue and irrigation charges, or the existing division of funds between the Government of India and Local Governments. The Commission shall, however, be at liberty to suggest means whereby the activities of the Governments in India may best be co-ordinated, and to indicate directions in which the Government of India may usefully supplement the activities of Local Governments.

Mr. F. W. B. Smith of the India Office and Mr. Janardan Atmaram Madan, I.C.S., will act as Joint Secretaries.

DR. D. CLOUSTON, M.A., D.Sc., C.I.E., has been placed on special duty for six months with effect from 3rd May, 1926, as Liaison Officer between the Royal Commission on Agriculture and the Government of India and the Local Governments.

DR. W. H. HARRISON, D.Sc., Imperial Agricultural Chemist, and Joint Director, Agricultural Research Institute, Pusa, has been appointed to officiate as Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa, *vice* Dr. Clouston.

DR. W. MCRAE, M.A., D.Sc., F.L.S., Officiating Imperial Mycologist, has been appointed to officiate as Joint Director, Agricultural Research Institute, Pusa, *vice* Dr. Harrison, in addition to his own duties.

MR. J. N. MUKHERJEE, B.A., B.Sc., First Assistant to the Imperial Agricultural Chemist, has been appointed to hold charge of the duties of Imperial Agricultural Chemist, *vice* Dr. Harrison.

DR. F. J. F. SHAW, D.Sc., A.R.C.S., Officiating Imperial Economic Botanist, Pusa, was on leave on average pay for one month with effect from 8th May, 1926.

DR. AMAR NATH PURI, M.Sc., Ph.D., A.I.C., who has been appointed to the post of Physical Chemist at the Agricultural Research Institute, Pusa, joined duty on the forenoon of 3rd May, 1926.

MR. W. SMITH, Imperial Dairy Expert, has been granted combined leave for five months and 18 days with effect from 29th April, 1926, Mr. Z. R. Kothavala, B.Ag., B.Sc., N.D.D., officiating.

MR. F. J. GOSSIP, Superintendent, Imperial Cattle Breeding Farm, Karnal, has been appointed to act as Assistant to the Imperial Dairy Expert with effect from 29th April, 1926, *vice* Mr. Z. R. Kothavala.

MR. B. C. BURT, B.Sc., M.B.E., Secretary, Indian Central Cotton Committee, Bombay, has been granted 7 months' leave on average salary with effect from 22nd April, 1926, or any subsequent date.

THE Government of Bombay have placed the services of Mr. W. J. Jenkins, M.A., B.Sc., at the disposal of Government of India for one year for appointment as Deputy Secretary, Indian Central Cotton Committee, Bombay.

DR. W. BURNS, D.Sc., Principal, Agricultural College, Poona, has been appointed to hold the temporary appointment of Joint Director of Agriculture, Bombay, for a period ending 11th October, 1927.

RAO BAHADUR P. C. PATIL, L.Ag., M.Sc., has been appointed to act as Principal, Agricultural College, Poona, *vice* Dr. W. Burns.

MR. G. B. PATWARDHAN, B.Sc., has been appointed to do duty as Economic Botanist to the Government of Bombay while remaining outside the Indian Agricultural Service, *vice* Dr. W. Burns.

DR. G. P. HECTOR, D.Sc., Economic Botanist to the Government of Bengal, has been granted leave on average pay for six months from 11th May, 1926.

MR. D. P. JOHNSTON, A.R.C.Sc.I., N.D.A., Deputy Director of Agriculture Punjab, has been granted leave on average pay for six months from 28th March, 1926. M. Charan Singh will remain in charge of the Montgomery Circle during Mr. Johnston's absence.

MR. D. MILNE, B.Sc., Director of Agriculture, Punjab, was on leave on average pay for one month from 20th May, 1926. Khan Saheb Maulvi Fateh-ud-din carried on the current duties of Director during Mr. Milne's absence.

COLONEL G. K. WALKER, C.I.E., O.B.E., F.R.C.V.S., Principal, Punjab Veterinary College, has been granted leave from 14th May, 1926, to 19th March, 1927 (including the College vacation), Mr. W. Taylor, D.V.H., M.R.C.V.S., officiating.

DR. H. E. ANNETT, D.Sc., F.I.C., M.S.E.A.C., Agricultural Chemist, Nagpur, has been appointed to officiate as Principal, Agricultural College Nagpur, in addition to his own duties, until further orders.

MESSRS. A. McLean, B.Sc., H. F. Robertson, B.Sc., R. Watson, N.D.A., and F. D. ODELL, B.A., Deputy Directors of Agriculture, Burma, have been confirmed in the Indian Agricultural Service.

REVIEW

Kitak Shastra : Manual of Entomology (in Marathi)—By V. G. Deshpande, B. Ag. (Bom.) Price As. 8.

One of the most encouraging signs of the times in the Bombay Presidency is the growth of a scientific literature in the languages of the province. Especially in Marathi has there been a considerable production of books in recent years. These are of moderate price, fairly popular and therefore easily accessible to the public purse and intellect. As examples of these we may mention :—

(१) वनस्पती चीं कुळें — Natural Orders of Plants, by S. L. Vaidya, L.Ag.
(२) फळझाडां चा बाग — Fruit-gardening, by H. P. Paranjpye, B.A.
(३) शाळेच्या बागेविषयी माहिती — School-gardening, by S. L. Vaidya, L.Ag.
(४) शेतकरी याचें अंकगणीत — Arithmetic for Farmers, by K. M. Pawar, B.Ag.
(५) पाठात्मक कृषिशास्त्र — Lessons in Agriculture, by K. M. Pawar, B.Ag.
(६) वनस्पती शास्त्र प्रवेश — A Short Treatise on Botany, by K. M. Pawar, B.Ag.

The most recent of these is an excellent little manual on insect life entitled कीटक शास्त्र (Kitak Shastra, Manual of Entomology) by Mr. V G. Deshpande, B.Ag. (Bom.), Lecturer in Entomology in the College of Agriculture, Poona. It is primarily a nature study book, but contains more material than is usually found in nature study books so-called, and it is suitable not only for schools but also for training colleges or for the growing number of amateur entomologists. The chapters on agricultural insect pests and the remedies for them are sure to be useful in villages and in rural education generally. Particularly worth commendation are the numerous illustrations. The author has had the good sense to stick to good clear line drawings and to avoid badly reproduced photographs. The illustrations are numerous, and one wonders how so many could be managed in a book of so moderate a price. It costs only eight annas.

The author has put much painstaking work into both letter-press and pictures, and we feel sure that in the Marathi speaking areas of both the Bombay Presidency and the Central Provinces this book will be greatly appreciated. [W. B.]

NEW BOOKS

On Agriculture and Allied Subjects

1. A Report on the Sugarcane Mosaic Situation in February 1924 at Soledad, Cuba, by Edward M. East, and William H. Weston, Jr. (Contribution from the Harvard Institute for Tropical Biology and Medicine.) Pp. vi + 52 + 9 plates. (London : Oxford University Press.) Price, 8*s.* 6*d.* net.
2. A History of Agriculture in Europe and America, by Norman S. B. Gras. Pp. 472. (London : Sir Isaac Pitman & Sons, Ltd.) Price, 15*s.* net.
3. The Physiology of Animal Breeding, with special reference to the Problem of Fertility, by F. H. A. Marshall and John Hammond. (British Ministry of Agriculture Research Monograph No. 2.) Pp. 45+6 plates. (London : Ministry of Agriculture). Price, 2*s.* net.
4. The Management of the Farm, by A Llewelhyn Moorhouse. Pp. xvii + 526. (New York and London : D. Appleton & Co.). Price 15*s.* net.
5. Grading Dairy Produce : Milk, Cream, Butter, Cheese, by G. Sutherland Thomson. Pp. viii+134. (London : Crosby, Lockwood & Son). Price 6*s.* net.
6. Variations in the composition of Milk : A study of the results of Analysis of Milk from Cows of various breeds throughout Scotland in 1921-22. Pp. 195. (London : H. M. Stationery Office). Price, 21*s.* net.

The following publications have been issued by the Imperial Department of Agriculture in India since out last issue : —

Memoirs.

1. Nutrients required for Milk Production with Indian Foodstuffs, by F. J. Warth, M.Sc., Labh Singh, L. Ag., B.Sc. (Ag.), and S. M. Husain, B.Sc. (Chemical Series, Vol. VIII, No. 9.) Price, As. 14 or 1*s.* 6*d.*
2. Silage Experiments at Nagpur, by Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., and A. R. Padmanabha Aiyer, B.A. (Chemical Series, Vol. VIII, No. 10.) Price, As. 10 or 1*s.*
3. Experiments on the Transmission of Rinderpest by means of Insects, by S. K. Sen, B.Sc., F.E.S. (Entomological Series, Vol. IX, No. 5.) Price, Rs. 2-4 or 4*s.* 2*d.*

ORIGINAL ARTICLES

THE AGRICULTURAL DEVELOPMENT OF THE CANAL TRACTS OF THE BOMBAY DECCAN*.

BY

T. F. MAIN, B.Sc.,

Deputy Director of Agriculture, South Central Division, Bombay Presidency.

The Bombay Deccan is that tract of country which lies to the east of a line drawn through Satara Town parallel to the coast line. On the north it touches Khandesh, and on the south merges into the Karnatak. It is an undulating country with a precarious rainfall and is, in many parts, subject to famine. The soil varies from rich black cotton soil through the medium grades up to the thinnest of *murum* lands. On the whole it is well suited to irrigation, but canals are expensive to construct, owing to the numerous *nallahs* which cut up the surface.

It has been the policy of Government for many years to devise measures for protecting this country from famine ; and a whole series of irrigation projects have been worked up, several of which have materialized into canals. There are in fact 32 schemes or projects based on the Ghat-fed rivers of the Bombay Presidency. I shall, however, confine my attention to the best eight protective projects in the Deccan. These eight schemes, when completed, will together bring some four million acres under canal supply, of which upwards of $1\frac{1}{2}$ million acres will be irrigable in normal years including upwards of two lakhs of acres under perennial irrigation, which, for practical purposes, means sugarcane. These schemes have not yet all materialized but the present position is approximately half a million acres irrigable on all canals ; or, in other words, the ratio of the present area to the full area, when these eight schemes are completed, is roughly one-third.

A curious feature of the development of these irrigated tracts has been the prominence given to sugarcane, whereas the primary motive for the construction of the canals was protection from famine. This feature is conspicuously noticeable in the tracts commanded by the more recently constructed canals. Thus on the Pravara canals where irrigation is developing very rapidly, this development is almost entirely restricted to cane cultivation, other crops being grown only for

* Paper read at the Indian Science Congress, Bombay, January 1926.

rotation purposes. This tendency is probably due in a large measure to the very favourable physical and climatic conditions of the Deccan for sugarcane, where the average crop is about three times as heavy as that of the United Provinces.

Recently, however, a change has come over the situation. The Great War had the effect of putting up the price of everything including both the cost of production and the value of the produce. While both effects lasted, sugarcane continued to be a very profitable crop, but unfortunately the value of the produce from cane has fallen whereas the cost of production has not. This phenomenon is particularly severe upon a crop which demands a very heavy expenditure ; and growing sugarcane in the Deccan has always involved a very heavy outlay because experience has shown that full crops can only be obtained through the application of exceedingly heavy doses of fertilizers. It has recently been computed that an average good crop of cane on the older canals costs the grower Rs. 800 (approximately) to produce. This expenditure should ensure a 32-*palla* crop to the acre (1 *palla*=210 lb.). Hence when the price of *gur* (raw, unrefined sugar) falls to Rs. 25 per *palla*, there is no profit left to the grower. All he gets is family wages.

During the last year or two there has been a very considerable lack of stability in the price of sugar and *gur* ; and the cause of this decline in value appears to be fairly obvious. The world production of sugar was greatly reduced during the war-years and the years immediately following the close of the war, but during the last three or four years there has been a rapid recovery and all the European beet-growing countries, with the exception of Russia and Poland, have reached pre-war production. In a recent issue of the "Sugar Planter" it was estimated that the world's production in 1924-25 amounted to 25 odd millions short tons, which means the significant fact that this production exceeds the previous record crop by no less than 14 per cent. Again the experience of sugar factories in the Deccan has not been very encouraging. Two such factories were established, but one at Baramati has gone into liquidation, and the other at Belapur has been undergoing a hard struggle, involving retrenchment.

As regards sugar, therefore, the future does not appear to be bright, while in the case of *gur* or *jaggery* the position is somewhat obscure. Some close observers do not think consumption in India will expand very much. If this proves to be the case and if the world is likely to increase its sugar production more rapidly than its sugar consumption, then there does not seem much scope for expanding the sugarcane area in the Deccan, unless the quality of its *gur* is such as to oust the Northern India *gur* from the market.

At this stage it is important to point out that the economic situation as outlined above has not yet become reflected in the actual area under cane in the Deccan. The latest figures show that the area has expanded from 13,590 in 1915-16 to 25,700 acres in 1924-25. This, however, is perhaps deceptive. New canal areas have been opened up, and in the early years very high yields can be obtained without

any special additional cost. Again the grower of sugarcane is a more or less specialized man and he finds it difficult to change his farming organization all of a sudden from a sugar basis to a non-sugar basis. The Indian Sugar Committee, in their report of 1920, pointed out that the then sugarcane area in the Deccan, approximately 30,000 (canals+wells) acres, could be expanded to 150,000 acres in the near future so far as irrigation facilities went, but in view of the foregoing remarks it seems doubtful whether these irrigated tracts should from an economic standpoint be developed on a sugarcane basis. The Bombay Agricultural Department has for some time past been studying this problem and is going carefully into alternative crops. It seems in fact very desirable to introduce a diversification of cropping on the Deccan canal areas.

The most promising alternative money crops are cotton and groundnuts. Certain other crops such as potatoes and turmeric may also find a place, but the market for the latter is not a very big one, while the potato crop involves many troublesome problems, notably the seed supply and the loss in storage from one cause or other. Groundnuts have already become well established on the Nira Left Canal where the area is now 6,000 acres, but perhaps cotton will ultimately prove to be the mainstay of the irrigated Deccan. At present the position is interesting. Everyone is familiar with the excellent financial results obtained with this crop, more or less throughout the whole of the Bombay Presidency and notably in Khandesh which forms the northern extension of the Deccan tract. Still, at present, there appears to be no great liking for this crop on the Deccan canals. On the other hand, there has been a great development of cotton growing on wells in the Sholapur District which is not far from these canals, where yields up to 1,500 lb. of seed-cotton per acre have been common on manured land. The canal cultivator appears to be under the impression that he should sow his cotton, if he grows it at all, on rain moisture and should save the cost of canal water. In this way the sowing date is apt to become late, *i.e.*, July, which in my opinion is much too late to enable early varieties of cotton like " N. R." to do themselves justice. This variety of cotton should be sown in the early part of June and possibly earlier. The Irrigation Department has accordingly fixed a very low water rate for cotton, amounting to Rs. 3 only for the *kharif* season (15th June to 15th October), but unfortunately the storage reservoirs do not always contain enough water to permit of irrigation being made available for cotton sowing so early as this. The agricultural problem of these irrigated tracts has thus assumed great significance, and a satisfactory solution is of the utmost importance. The problem is two-sided : (1) the economic, and (2) the technical.

On the economic side we have got to ascertain the most appropriate combination of crops and their relative distribution in point of area, taking into account, on the one hand, the quantities of water available in the storage reservoirs at each period of the year, and, on the other hand, the market demand for and price of the produce, and also the amount of labour required and available in different seasons.

On the technical side we have got to investigate the possibilities of reducing the cost of production of cane and the scope for increasing the outturn by breeding varieties more thrifty in their utilization of fertilizers. We have also to work out the possibilities of alternative money crops like cotton. Research on these lines is in progress, and already substantial progress has been made in reducing the cost of cane production. Thus Rao Bahadur Patil claims to have perfected methods, initiated by Professor Knight, which enable a saving in cost of production of approximately Rs. 130 to Rs. 160 per acre. Looking at the problem as a whole, I am inclined to draw the tentative conclusion that a solution will be found on the basis of restricting the cane area to something much below that formerly contemplated, and turning the water thus saved to account by growing alternative money crops, and, in addition, materially reducing the cost of producing a unit of sugar or *jaggery*.

Discussion.

Mr. G. L. Kottur pointed out the danger of continued fragmentation of holdings in the irrigated tracts and the necessity of determining the minimum size of an economic holding in the canal areas.

Mr. W. J. Jenkins, referring to the introduction of the cultivation of alternative crops to sugarcane, *e.g.*, cotton and groundnuts, in the Deccan canal areas, pointed out that such introduction should be properly controlled and managed from the beginning. Otherwise there might be some danger that wholesale introduction under irrigated conditions would tend to reduce the value and reputation of such crops at present grown under dry conditions.

Rao Saheb Bhimbhai M. Desai, referring to the present unprofitableness of sugarcane cultivation, suggested a heavy duty on imported sugar. He pointed out the agricultural advantages of increasing the cultivation of suitable crops in rotation with sugarcane.

Mr. B. S. Patel stated that the successful introduction of new crops in the canal areas would largely depend upon the encouragement given to growers by the Irrigation Department, in whose hands the business management of the canals rested. He advocated concessions and reductions in the water rate to approved cultivators.

Mr. Main said that, in the Bombay Presidency, a sliding scale of water rate for cane-growers, varying with the rise and fall of *gur* prices, was under contemplation. He thought such an arrangement would be a good one.

Mr. Salimath enquired if any information was available with regard to the yield of irrigated cotton in the Bombay Deccan.

Mr. Main replied that yields of *kapas* up to 800 lb. per acre had been obtained under irrigation at the Manjri farm near Poona. Further investigations to determine yield possibilities were necessary.

STALLS AND HARNESS USED IN THE STUDY OF NITROGEN METABOLISM AND NUTRITIVE VALUE OF CATTLE FEEDS.

BY

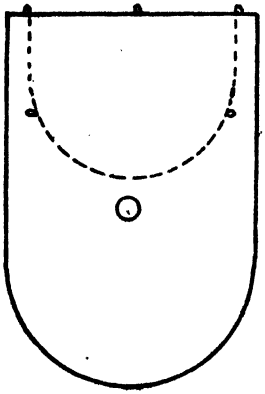
P. E. LANDER, M.A., D.Sc., A.I.C.,

Agricultural Chemist to Government, Punjab, Lyallpur.

THE stalls and harness used for collecting dung and urine from the bullocks and cows, described in this paper, are the result of experience gained in trials carried out at the Lyallpur Research Institute during the winters of the past four years. Preliminary work was undertaken with bullocks in a stall, the floor of which was of the ordinary type—brick in lime—but with a slight depression in the centre which sloped towards one side, the object of this being to prevent any urine which might escape, from coming into contact with the dung bag when the animal lies down.

The bag for collecting dung was suspended from a metal frame covered with leather, and arranged so as to fit the hind parts of the animal, and kept in position by cotton tape having short pieces of rubber tubing interpolated in order to give some " play," and tied at the other ends round the neck of the animal. Both the metal frame and the method of tying it from the neck were soon found to be unsatisfactory on account of wounds produced by friction against the tender skin of the animal and were hence discarded. The dung bag was then applied direct to the animal, whose tail was kept inside the bag, which latter was held in position as before by cotton tapes with short rubber connecting links, but fastened at the other ends with a stuffed belt passing round the girth of the animal. The placing of the animal's tail in the bag simplified the construction of the mouth of the bag but had certain obvious disadvantages, hence the tail was passed through an opening made in the upper flap of the bag. When passing dung, the animal lifts its tail slightly but with considerable force and this keeps the two flaps of the bag open, thus permitting the dung to fall unobstructed to the bottom of the bag.

The general design is shown in Plate XIX, fig. 1. The lower flap of the bag in contact with the animal is cut into the shape as shown in the text-figure. This method was found to work with entire satisfaction.



The animal was curryed twice daily—morning and evening—when the dung was transferred from the bag into a closed receptacle.

The digestibility coefficients obtained when working with this apparatus have already been published, [1] from which it will be seen that some of the figures obtained, including those for nitrogen, were negative. Such figures are not uncommon when poor feeds such as *bhusa* (wheat straw) are being fed. It was considered advisable to study the nitrogen metabolism in such cases, for which purpose it was necessary to collect uncontaminated urine.

The usual bag and rubber tube attachment has been described by Warth[2] in connection with his nitrogen metabolism stall for bullocks. In this the animal is always made to sit sideways by giving a gentle slope towards, and ending in a deep depression near the centre of one side. An elaborate system of pulleys guides the urine tube to a receiver in a pit through a glass tube. This design has been considerably modified though in principle it remains unaltered. The system of three long pulleys was replaced by a single short pulley at the end of a wooden peg fixed in the side of the pit (Plate XIX, fig. 1). A wire hook on the pulley keeps the urine tube in position. The vertical glass tube and the receiver were replaced by a galvanized metal cylinder three feet deep and six inches in diameter, thus giving the animal plenty of movement backwards and forwards. About three-fourths of the floor was levelled and the deep depression on the side scooped and extended to almost the middle of the floor. Uncontaminated urine was collected over periods of 16 days, and it is rare to find that the urine tube gets under the legs or the body of the animal. Although this works well there is the disadvantage

[1] *Mem. Dept. Agri. India Chem. Ser.*, VII, No. 4.
[2] *Agri. Jour. India*, XVIII, p. 267.

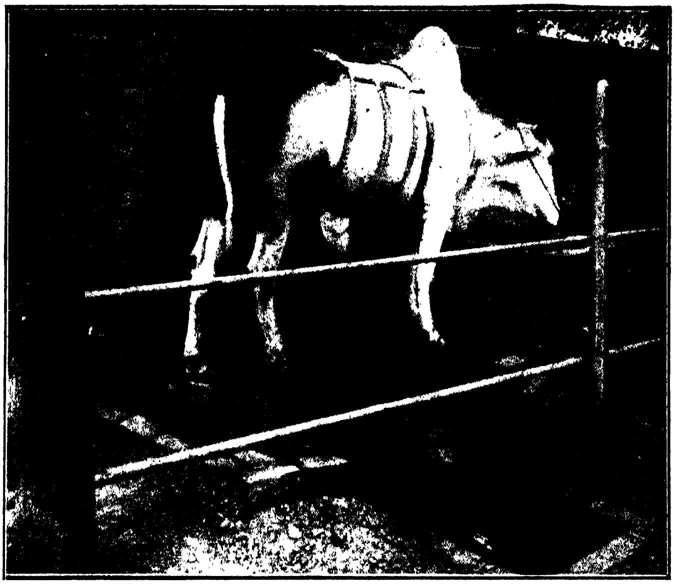


Fig. 1.

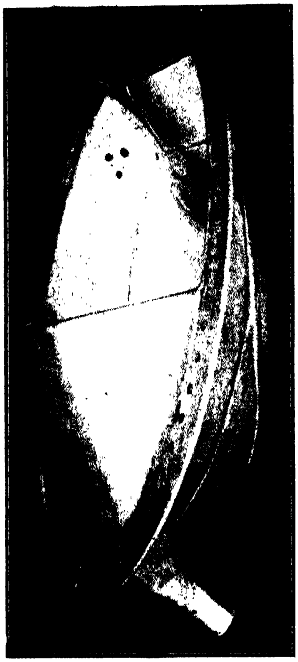


Fig 3.

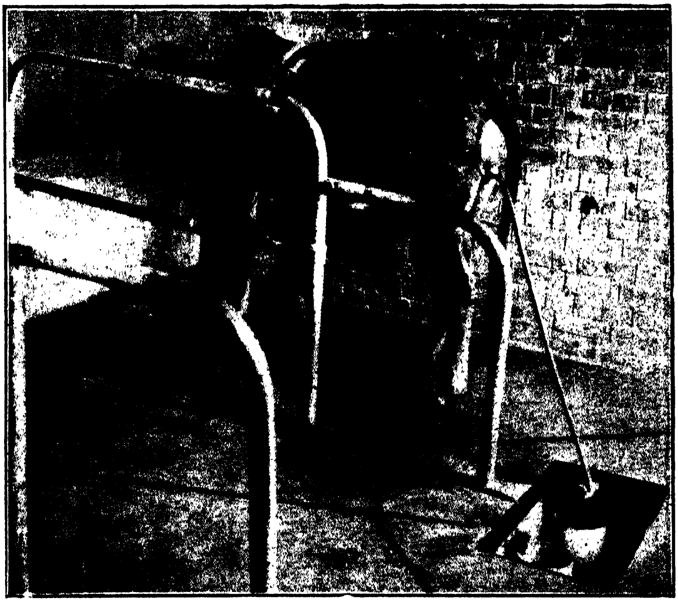


Fig. 2.

STALLS AND HARNESS USED IN THE STUDY OF NITROGEN METABOLISM AND NUTRITIVE VALUE OF CATTLE FEEDS.

to the animal that it is restricted to sitting on the same side always. In one of our trials this so annoyed one of the animals that he persisted in sitting on the reverse side, and would have slid down into the side pit had the stays on this side of the pit not been sufficiently strong. Plate XIX, fig. 1 shows the modified stall, in which considerable improvement may still be effected if the animal is to be free from all restraint.

The stalls for conducting the experiments on cows were constructed in October 1924 and are shown in fig. 2 on Plate XIX, which also shows a cow with the harness on. The floor and manger are of concrete and can be kept quite clean. Each stall is separated from its neighbour by iron pipes as shown, so that an animal cannot get at the food of its neighbour. In the earlier trials a tin of water was placed on the floor of each stall for the animals, but this arrangement has now been modified by fixing a galvanized trough flush at the end of each individual manger. The black lines on the floor merely indicate the direction of the slope.

A milch cow is a very sensitive animal, and the harness, therefore, must be light and comfortable. The dung bag was accordingly dispensed with and the dung either received in a cup by an attendant as it is voided by the animal, or picked up without loss or contamination from the floor. One attendant can conveniently manipulate four cows. The urine for the study of nitrogen metabolism is collected by the assistance of a cup arrangement held against the hind-quarters of the animal in a leather piece which is in turn strapped to a stuffed belt encircling the girth of the animal as in the case of the bullocks. Fig. 3 on Plate XIX shows the details of the cup which have to be modified to suit each animal. To the posterior orifice of the cup is attached a rubber tube weighted at the other end, and of a diameter sufficiently great to prevent urine from overflowing. This tube passes over a system of three short rollers placed at an angle in the cover into a tall cylindrical receiver standing in the pit. The receivers are of the same dimensions as those employed for bullocks. The parts of the cup which require special mention are :—

(*a*) Curvature on the top which allows the dung to pass out freely.
(*b*) Holes on the rim of the cup by which it is attached to the leather piece, and the ventilation holes on the back of the cup.
(*c*) The protruding curved rim on the interior which holds the lip of the hind-quarters and thus prevents leaking of the urine.

As a safeguard against any chance-leak from the cup the slope on the clean cement floor guides any urine which may escape to the receiver and the floor is immediately washed down with a small quantity of water into the receiver ; a leakage, however, is rare and such washing is rarely resorted to, and as far as any outward signs indicate, the animals have not suffered discomfort and urine has been satisfactorily collected for 22 days at a stretch.

To keep an animal in a fit condition during the course of such a trial some exercise is necessary, generally attained by giving the animal a brisk walk of about two miles ;

one attendant leads two cows and another walks behind with receptacles to receive the urine and dung separately as they are passed. Usually the animals pass urine or dung either at the start or at the finish, and no trouble has been experienced or any loss occasioned during these excursions.

On the whole, the apparatus works extremely well and appears to have overcome the difficulty of efficiently separating urine from dung in the case of cows under such experiments.

The experimental data and the results obtained in the trials under progress with this harness will be presented in detail and discussed elsewhere.

In conclusion, I should express my obligation to Pandit Lal Chand Dharmani, L.Ag., B.Sc. (Agri.), Research Assistant, and Sardar Sahib Jagat Singh, M.Sc., Assistant Professor of Chemistry, for their assistance during the progress of the work, and for exercising patience and ingenuity in perfecting the apparatus, and to Mr. Brownlie, Agricultural Engineer, for valuable help in constructing the shed.

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, MR. J. T. EDWARDS (*on leave*) : *Secretary for Publications*, MR. S. K. SEN).]

VII. HÆMORRHAGIC SEPTICÆMIA IN CATTLE IN INDIA.

BY

S. C. J. BENNETT, B.Sc., M.R.C.V.S.,

Late Second Bacteriologist, Muktesar.

HÆMORRHAGIC septicæmia stands in India second in importance only to rinderpest among the contagious diseases of cattle ; but while rinderpest occurs continuously throughout the year, hæmorrhagic septicæmia has a seasonal as well as a regional prevalence. Generally speaking, it is a disease of the rainy seasons : the largest outbreaks occur during the summer monsoon and the smaller ones during the " Christmas rains." In the past many outbreaks were diagnosed as anthrax owing to the rather close similarity of some of the clinical symptoms of the two diseases, but at the present time it is probable that all outbreaks of hæmorrhagic septicæmia are correctly diagnosed.

The cause of the disease is a small bacterium of the so-called " pasteurella " or " hæmorrhagic septicæmia " group. This group of bacteria is an extensive one, comprising all the organisms which cause the hæmorrhagic septicæmias of animals and human plague. The bacteria are easily cultivated in artificial media, and it is of great interest that they have been grown in ordinary spring water containing organic substances and in garden soil. Another notable feature of the bacteria of this group is that they lose their virulence in artificial culture media but regain it, or even become " exalted " in pathogenicity, when inoculated into suitable susceptible animals. One thus understands that they may live and grow in marshy areas, remaining meanwhile in a low state of virulence, but when an animal of more than ordinary susceptibility is introduced into the locality, it may be infected with large numbers of these organisms and develop the disease ; and the microbes, after having overcome the animal's natural defences, may become so exalted in virulence that when voided in the discharges of the animal they are in a position readily to invade the tissues of a second animal, so that the disease eventually takes the form of a veritable outbreak. It is on this account that outbreaks of hæmorrhagic septicæmia are comparatively " explosive " in nature.

The hæmorrhagic septicæmias of cattle and buffaloes have generally been represented, particularly in text-books of veterinary pathology, as separate entities, buffaloes being regarded as more susceptible to the disease. There does not, however, appear to be at present any valid evidence to indicate that the buffalo and domestic cattle are not infected by the same species of organism. On the other hand, it is probable that the causative organisms in both cases are identical, inasmuch as either animal may be protected against natural or artificial infection by the use of equal doses of serum prepared with a single " strain " of bovine hæmorrhagic septicæmia organisms. With regard to the comparative susceptibility of the two classes of animals, it has been noticed at the Muktesar Institute that, so far as artificial inoculation is concerned, they exhibit no difference in susceptibility, so that the question as to the possibility of the buffalo being more susceptible than cattle under natural conditions must be considered in relation to the different habits of life and to the conditions in which the two classes of animals are maintained. In short, it may be considered that domestic cattle and buffaloes are of approximately equal susceptibility although greater opportunities are afforded to the latter for acquiring the disease.

Natural infection probably occurs in most cases by way of the digestive tract, although it is not improbable that in some cases the bacteria are introduced through abrasions of the skin or mucous membrane of the mouth. In this connection it is of interest that the feeding of artificial cultures to cattle will rarely produce the disease although it may be produced by any of the other common methods of artificial infection. In view of the correlation frequently observed between the incidence of hæmorrhagic septicæmia and the abundance of blood-sucking flies, it is also not improbable that in some cases these act as intermediaries in the mechanical transmission of the disease. Apart from these considerations it is generally recognized that infection is acquired by way of the mouth, and the great swelling of the throat that is observable in natural (but not in experimental) cases of the disease, may perhaps be taken as evidence in support of this view. After the appearance of the first few cases in a herd the outbreak may cease spontaneously, in which case one is said to have encountered a few sporadic cases ; or the outbreak may extend with great rapidity within a comparatively limited area resulting in heavy mortality. In no case, however, is the outbreak likely to continue over a long period as in the case of rinderpest, nor is it likely to be carried to any long distance from the site of the original outbreak. On the contrary, the removal of animals is more likely to cut short the enzootic.

The symptoms of hæmorrhagic septicæmia are, in all but the most rapidly fatal cases, fairly characteristic. The " incubation period " may be from several hours to two days or more. With the rapid onset of symptoms death is usually early and may occur in from 18 to 24 hours, and in such rapidly fatal cases the symptoms to be observed are almost negligible, a rise of temperature being sometimes hardly appreciable, unless it is taken at very short intervals. In the less severe cases death

occurs in about two days and the rise of temperature is well marked, and usually extreme, frequently attaining 106° F. to 107° F. In most cases the onset of the disease is characterized by shivering and the animal soon shows signs of lameness. Once the lameness has appeared, swellings begin to develop either in the limbs, or, where they are more noticeable, on the head and the neck. Often there are signs of pain in the abdomen, which looks distended, although no fæces are at first voided. Later, the symptoms are aggravated and the respiration is harsh and rapid, diarrhœa sets in and the lameness and swellings increase, until at length the animal is incapable of locomotion. During the last stages the animal may be seen standing with its head thrust forward and there is a copious discharge of tears and saliva. Respiration is very rapid and every sign of impending asphyxia is presented : occasionally the animal attempts to cough but appears to be unable to do so. The animal remains on its feet as long as it is capable of doing so, but it will not attempt to move and all efforts to induce it to do so are of no avail. Eventually it collapses and dies rapidly —so rapidly in some cases that it may be said without exaggeration that the animal has "dropped dead." In the naturally occurring disease there is a progressive tense swelling of the throat and head, attaining to such a degree that the animal is sometimes almost unrecognizable : in the experimentally induced infection the cervical swellings are rare but swellings of the limbs and lameness are more common. The description given above does not, however, represent the entire train of symptoms observed in every case although it purports to be a general clinical picture of the disease whether cattle or buffaloes are concerned. It is difficult to state accurately the percentage of mortality due to hæmorrhagic septicæmia, but experience has shown that no animal recovers after having shown more than the mildest symptoms. Recoveries have been observed in cases where evidences of early infection have been obtained by laboratory tests, but in such cases the animals concerned suffered from what would appear to be almost a symptomless attack of the disease. In this connection mention may be made of the observations made by many veterinary officers in the field that young animals appear to be more susceptible than adult ones ; this may without doubt be attributed to the fact that among the older animals there is a large proportion that has recovered from a mild form of the disease.

Diagnosis of hæmorrhagic septicæmia from the symptoms alone should not be difficult, although in the past the disease has often been confused with anthrax. In this connection it would appear that too much stress has been laid on the presence of swelling of the throat in cases of anthrax. Oedema of the cervical region is a character of anthrax chiefly in horses and mules but is of comparatively rare occurrence in cattle, while, on the other hand, a swelling of the throat is a fairly constant symptom of naturally occurring bovine hæmorrhagic septicæmia. Any animal that has died suddenly with a greatly swollen throat should be first suspected as having died of hæmorrhagic septicæmia rather than of anthrax. A definite diagnosis is always to be made by the examination of a stained blood smear. In the

case of hæmorrhagic septicæmia the bacteria, which are usually present in the blood in immense numbers, are very small, ovoid, and stain only at the poles, whereas the anthrax bacillus is very large, square-ended, often in short chains, and stains evenly ; it has, moreover, a well-defined capsule which may be seen in all cases in which the carcase is not in a state of excessive disintegration. It should be remembered, however, that in some cases of hæmorrhagic septicæmia the bacteria are found in the blood only with extreme difficulty and after prolonged examination of a blood smear, and in such cases the rare occurrence of bacteria (if the carcase be fresh) is almost differentially diagnostic of hæmorrhagic septicæmia, since in anthrax the bacilli nearly always occur in large numbers. *Post-mortem* examination of a carcase for diagnostic purposes would hardly be of any value, in view of the rapidity with which carcases tend to disintegrate in the tropics, and, moreover, anthrax carcases should, on principle, never be opened.

It will thus be seen that although hæmorrhagic septicæmia may at times be confused with anthrax, a mistaken diagnosis should be comparatively rare, the more so in view of the fact that, as a rule, multiple cases occur, so that even if a definite diagnosis cannot be made in the case of one animal, it should be possible to make one in another and so to establish the nature of the outbreak.

Prevention and control.

The seasonal and regional incidence of the disease suggests that the most reasonable method of preventing outbreaks will be to prevent susceptible animals from grazing over known infected areas during the rainy seasons. Such a procedure in India would, however, be quite impossible as a general measure, and attention must therefore be directed towards some form of prophylactic treatment. Two products are prepared on a large scale at the Muktesar Institute for this purpose, namely, a hyper-immune serum and a vaccine.

As a routine prophylactic agent for use in the field, anti-serum is not ideal, since, in common with all other anti-sera, the period over which it protects an animal is very short, indeed far shorter than the period during which outbreaks are liable to occur in infected areas. In order to meet this objection a vaccine has been prepared and is now issued on a large scale for the prophylactic vaccination of cattle, and reports received from the Civil Veterinary Departments of the various provinces for some years past have shown that its administration is of great value in reducing the incidence of hæmorrhagic septicæmia. In most districts the vaccine is injected into as many cattle as possible in the infected areas at the commencement of the rains, but in some districts other procedures are adopted. In some cases, only young stock are vaccinated on a large scale in anticipation that superimposition of a natural infection will induce the development of a stronger immunity which will be of a lasting nature. In still other districts, specially irrigated districts, it has been noticed that the seasonal occurrence of the disease is not so marked as it is elsewhere

and on this account, whilst vaccination is extensively practised, there is no special time of the year at which the operation is performed. It is impossible to keep detailed and accurate records of vaccinations and results, and it is further not possible to keep any animal or animals (except rarely) under observation from year to year, and therefore the reports available are to a large extent in the nature of circumstantial evidence. Reference to the Annual Reports of the Provincial Civil Veterinary Departments and to those of the Muktesar Institute will, however, show that the number of vaccinated cattle which die throughout India is proportionately very much less than that of the non-vaccinated. Thus in the present state of our knowledge of this disease and in consideration of the circumstances in which veterinary work in India is being carried out, it appears that the most suitable prophylactic measure that is capable of general application is the extensive administration of vaccine.

For the control of outbreaks when once the disease has made its appearance other methods are to be recommended. Having regard to the regional incidence and the enzootic character of the disease, susceptible animals should be removed from the scene of an outbreak, preferably into buildings, if these are available. As is the case with many other desirable recommendations, this procedure is rarely possible in India, but when it has been adopted, the results have been satisfactory.

In the great majority of outbreaks it is necessary to institute some form of treatment at the site of the outbreak. At the outset it may be said that there is no "cure" for hæmorrhagic septicæmia in that any animal which shows marked symptoms will almost certainly succumb; nor is there any form of medical treatment of proved value in protecting the healthy animals in an infected herd, even for the shortest period of time. If it is impossible to remove all animals to a distance, or even if this is possible, the administration of anti-hæmorrhagic septicæmia serum is the most certain way to cut short the outbreak. The serum has a great advantage over vaccine in that it begins to exert its protective power almost from the moment it is injected, whereas in the case of the vaccine it is known that some days must elapse before immunity develops. Of the efficacy of the anti-serum there is now little doubt, as has been shown by severe and definite laboratory tests; in addition, all veterinary officers in the field, who have had recourse to it in dealing with outbreaks of hæmorrhagic septicæmia, have reported on its efficacy in most favourable terms. The technique to be adopted in giving the serum is less variable than in the case of vaccine. All in-contact animals should be treated. The question of the mixing of healthy animals which have received serum, with the diseased ones, has received some attention, because it is known that in the case of cattle which have received serum and the causal bacteria of the disease, the immunity developed is more lasting. In the case of hæmorrhagic septicæmia, however, it seems that the mixing of the infected animals with those that have been given serum, while it may be of some value, is not of such importance as in the case of rinderpest, in which

this procedure is strongly advocated. This is partly attributable to the fact that in hæmorrhagic septicæmia the "incubation period" and the period during which an affected animal is a potential source of danger are both very short, and perhaps also to the fact that immediate contagion from the disease to the healthy animal rarely, if ever, occurs.

The foregoing arguments will show that for prophylactic purposes the vaccine is to be preferred and that for the controlling of outbreaks the use of serum is necessary. These are, however, not the only products that have been employed in attempts to reduce losses from this disease, and the question of hæmorrhagic septicæmia control cannot be closed without a brief reference to some of the others.

It must be understood that the vaccine that has been in use throughout India in recent years, contains only killed hæmorrhagic septicæmia bacteria and their products. Many attempts have been made in this and in other countries to make use of the knowledge that the bacteria lose their virulence with more or less rapidity when grown in artificial culture media, the object having been to obtain bacteria of such a degree of "attenuated" virulence that they will not cause death when inoculated alive into a susceptible animal. It has been claimed that such an attenuated vaccine would produce a more lasting immunity than a dead one. Unfortunately, however, all cattle are not equally susceptible to hæmorrhagic septicæmia, and even with a very attenuated living vaccine it is not certain that some of the more susceptible cattle would not die as the result of vaccination. Apart from the destruction of the confidence of the uneducated cattle-owners (and they constitute the majority), such an accident would be dangerous also in virtue of the exaltation in virulence that the bacteria would undergo, so that a serious outbreak might follow. Further, the efficacy of attenuated living vaccines has not yet been proved to be greater than that of dead vaccines, and in consideration also of the potential dangers of using them they are not to be recommended for use in India.

Another method of immunization against hæmorrhagic septicæmia that is worthy of attention may be referred to as the "simultaneous" method, being in principle similar to the method of that name, which has been employed in India and elsewhere in protecting cattle against rinderpest. It is known that in the case of rinderpest a lasting, probably lifelong, immunity can be set up by this method, and similar forms of immunization have been recently employed in the case of certain human diseases. Experiments that have been recently conducted at the Muktesar Institute have shown that a "simultaneous" immunization against hæmorrhagic septicæmia can be performed with safety and that the immunity is of comparatively long duration. All the necessary details have not, however, been worked out, and the method is not yet available for general use.

Results fairly satisfactory in character are being obtained by the methods at present in use for combating the disease, so that it would seem hardly wise to recommend a new form of treatment for general acceptance until its efficacy has been more exhaustively tested under laboratory conditions.

WOOD ASHES AS AN AMELIORANT OF SOIL ACIDITY.

BY

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A GOOD deal of work has been done on soil acidity by Mr. Meggitt, late Agricultural Chemist to the Government of Assam, and it was he who first pointed out that a high degree of acidity, as is commonly met with in the soils of Assam, is positively toxic or injurious to many cultivated crops, especially the *rabi* (winter) crops of Assam.

The present paper deals with experiments originally started by Mr. Meggitt and carried on by the writers for two years after he left.

During the early years several crops of oats and mustard were grown on different areas of the farm and though well-manured with cowdung they all failed. The failure of these crops was at first attributed to lack of soil moisture, but later on it was found that the soil did not lack in adequate moisture when the crops failed. It so happened, however, that a small part of the area on which these crops were sown, accidentally received a dressing of wood ashes thrown out from the sugar boiling furnaces nearby. On the land so treated quite a good crop matured. This was at once suggestive. As the wood ashes are alkaline, experiments were started on the effects of wood ashes on various crops, aside from lime, as they are easily available and cheaper for the common cultivators of Assam.

Accordingly, five plots were taken up and were treated with 5, 10, nil, 15 and 20 maunds of wood ashes per acre per annum respectively. One-half of each of these plots was cross-dressed with cowdung at the rate of 100 mds. per acre per annum. For the first three years *aus* paddy was followed by oats in the cold weather. Each successive year the effect of wood ashes became more and more pronounced, and

at the end of the third year the plots manured with cowdung gave certain decisive results as tabulated below :—

Plot No.	Application	Oats in grain
1 *a*	5 mds. wood ashes alone	No crop.
1 *b*	5 mds. wood ashes + 100 mds. cowdung	No crop.
2 *a*	10 mds. wood ashes alone	No crop.
2 *b*	10 mds. wood ashes + 100 mds. cowdung	238 lb.
3 *a*	No wood ashes	No crop.
3 *b*	No wood ashes + 100 mds. cowdung	No crop.
4 *a**	15 mds. wood ashes	..
4 *b*	15 mds. wood ashes + 100 mds. cowdung	476 lb.
5 *a**	20 mds. wood ashes	..
5 *b*	20 mds. wood ashes + 100 mds. cowdung	826 lb.

* The figures were not recorded.

In the fourth year, cowpeas were grown as a green manure in the rains on all plots followed by oats in the cold weather. In view of the green-manuring no cowdung was applied. The seedlings died out on the plots receiving no wood ashes (Plots Nos. 3 *a* and 3 *b*) and also on those dressed with 5 mds. and 10 mds. wood ashes without cowdung (Plots Nos. 1 *a* and 2 *a*). All the other plots matured crops and the outturn increased with the amount of wood ashes applied. Unfortunately, no figures were available as the crops were spoiled after the harvest, before being weighed.

The experiment was continued till the end of the twelfth year from the commencement. The results from the fifth year till the end of the twelfth year are arranged in Tables I and II. During the fifth year cowpeas were grown as a green manure in the rains followed by oats in the cold weather. The seedlings died out on the plots receiving no wood ashes. The other plots matured crops and the yield increased with the amount of wood ashes applied. In the sixth year *jowar* (*Sorghum vulgare*) was followed by *kultikalai*. The latter crop which was a new introduction to the farm was sown too late. Though it made a good vegetative growth, it failed to ripen its seeds before the rains ruined it and consequently no figures were obtained. The *jowar* was cut green for fodder and the yield increased largely with every increase in the amount of wood ashes used. The plots without wood ashes as well as the plot with 5 mds. wood ashes without cowdung, failed to produce any crop whatsoever. Cropping for the seventh year was cowpeas as a green manure followed by oats. Plots Nos. 1*a*, 2*a*, 3*a* and 3*b* did not mature any crop, while the other plots gave similar yields as before. Soybeans were tried in the eighth year. The crop increased with increasing doses of wood ashes, the cowdung section of the plot being better in each case. But, unfortunately, due to an outbreak of disease the crops were damaged and consequently no figures were available. Again, in the ninth year cowpeas were sown in the rains followed by

TABLE I. *Showing the effects of wood ashes and cowdung on oats, jowar and arhar in the acid soils of Jorhat farm.*

No. of plots	Application	Acidity parts CaO per million grm. soil	5th year Crop Summer	5th year Crop Winter	5th year Yield Oats in grains	6th year Crop Summer	6th year Crop Winter	6th year Yield Green Jowar	7th year Crop Summer	7th year Crop Winter	7th year Yield Oats in grains	8th year Crop Summer	8th year Crop Winter	8th year Yield	9th year Crop Summer	9th year Crop Winter	9th year Yield	10th year Crop Summer	10th year Crop Winter	10th year Yield	11th year Crop Summer	11th year Crop Winter	11th year Yield Oats in grains	11th year Yield Green Jowar	12th year Crop Summer	12th year Crop Winter	12th year Yield Arhar in grains
					lb.			lb.			lb.												lb.	lb.			lb.
1b	5 mds. wood ashes + 100 mds. cowdung.	560	Cowpeas green-manured	Oats	280	Jowar	Kultikalai (failed to ripen)	1,211	Cowpeas green-manured	Oats	165	Soy beans (damaged)			Cowpeas green-manured	Rape (damaged)			Para peas (damaged)		Jowar	Oats	42	1,232		Arhar	120
2b	10 mds. wood ashes + 100 mds. cowdung.	571			553			3,689			210												420	4,354			630
3b	No wood ashes + 100 mds. cowdung.	795			nil			nil			nil												nil	nil			40
4b	15 mds. wood ashes + 100 mds. cowdung.	605			574			8,456			434												616	11,025			1,110
5b	20 mds. wood ashes + 100 mds. cowdung.	554			574			11,284			435												1,050	20,111			1,780

TABLE II. *Showing the effects of wood ashes alone on oats, jowar and arhar in the acid soils of Jorhat farm.*

No. of plots	Application	Acidity parts (CaO per million grm. soil)	5th year Crop Summer	5th year Crop Winter	5th year Yield Oats in grains	6th year Crop Summer	6th year Crop Winter	6th year Yield Green Jowar	7th year Crop Summer	7th year Crop Winter	7th year Yield Oats in grains	8th year Crop Summer	8th year Crop Winter	8th year Yield	9th year Crop Summer	9th year Crop Winter	9th year Yield	10th year Crop Summer	10th year Crop Winter	10th year Yield	11th year Crop Summer	11th year Crop Winter	11th year Yield Oats in grains	11th year Yield Green Jowar	12th year Crop Summer	12th year Crop Winter	12th year Yield Arhar in grains
					lb.			lb.			lb.												lb.	lb.			lb.
1a	5 mds. wood ashes.	571	Cowpeas green-manured	Oats	nil	Jowar	Kultikalai (failed to ripen)	nil	Cowpeas green-manured	Oats	nil	Soy beans (damaged)			Cowpeas green-manured	Rape (damaged)			Para peas (damaged)		Jowar	Oats	14	133		Arhar	40
2a	10 mds. wood ashes.	605			nil			392			nil												56	819			220
3a	No wood ashes	[illegible]			nil			nil			nil												nil	nil			20
4a	15 mds. wood ashes.	588			95			2,079			98												252	2,737			480
5a	20 mds. wood ashes.	482			360			5,243			375												728	8,673			1,220

rape in the cold season. The cowpeas were hoed in as a green manure. Rape was sown very late on account of late rains and it made a miserable show. Similarly, in the tenth year the plots were sown with parapeas in the autumn but the seeds could not germinate on account of heavy showers after sowing and even those which survived were destroyed by crickets. No figures were, therefore, available for record. Cropping for the eleventh year was *jowar* followed by oats in the cold season. Both these crops gave higher yields in comparison with those of preceding years. Plots Nos. *3a* and *3b* without any wood ash did not mature any crop. Plots Nos. *1a* and *2a* with an application of 5 mds. and 10 mds. of wood ashes without cowdung, which failed to mature any crop in the previous years, gave an outturn of 14 lb. and 56 lb. of oats in grains respectively. This was quite clear and convincing to show the accumulative effect of wood ashes as an ameliorant of soil acidity.

Arhar (*Cajanus indicus*) was grown in the twelfth year. All the plots matured crops and the outturn increased with increased doses of wood ashes applied. Of all the crops tried, *arhar* was the single instance which produced a certain amount of crop from plots without any application of wood ashes.

The results of the experiments on the effects of wood ashes on oats, *arhar* and *jowar* are shown in Tables I and II and in the curves in Figs. 1 and 2, of which one is for cowdung and wood ashes combined and the other for wood ashes alone. The abscissæ and the ordinates in the curves represent the amount of wood ashes applied and the yield of crop respectively.

Besides, to study the accumulative and residual effects of wood ashes in the soil, the acidity was separately determined at the close of the experiment for each plot according to Hopkins method. The results are shown in the tables and curves mentioned above. The abscissæ and the ordinates represent the amount of wood ashes applied and the acidity in parts of lime per million parts of soil respectively.

From Tables I and II and the curves in Figs. 1 and 2 it is clearly shown that the yield of crop increased with increasing doses of wood ashes in both the sections with and without cowdung, and the cowdung plots gave better outturn of crops than those without any application of cowdung. The results also point out that the infertility of the soil is due to soil acidity as well as to lack of available plant food in the soil.

When the process of soil acidification establishes itself in a marked degree, due to leaching of lime or other complicated causes, especially in a region where the rainfall averages 80 inches or more per annum, the removal of other plant foods, notably phosphoric acid, in drainage water becomes inevitable. From the analysis of the said farm soil the percentages of total and available phosphoric acid (P_2O_5) were found to be 0·02 per cent. and 0·005 per cent. respectively, which are indeed very low. The process of soil acidification thus leads to a general impoverishment and toxicity of the soil.

That acidity has distinct harmful effects on certain crops is noticed in Tables I and II and the curves for oats and *jowar* in Figs. 1 and 2 respectively. It is also

evident from the tables and curves that, where the wood ashes are not applied or applied at a very low rate, the higher soil acidity does not allow the crops to grow.

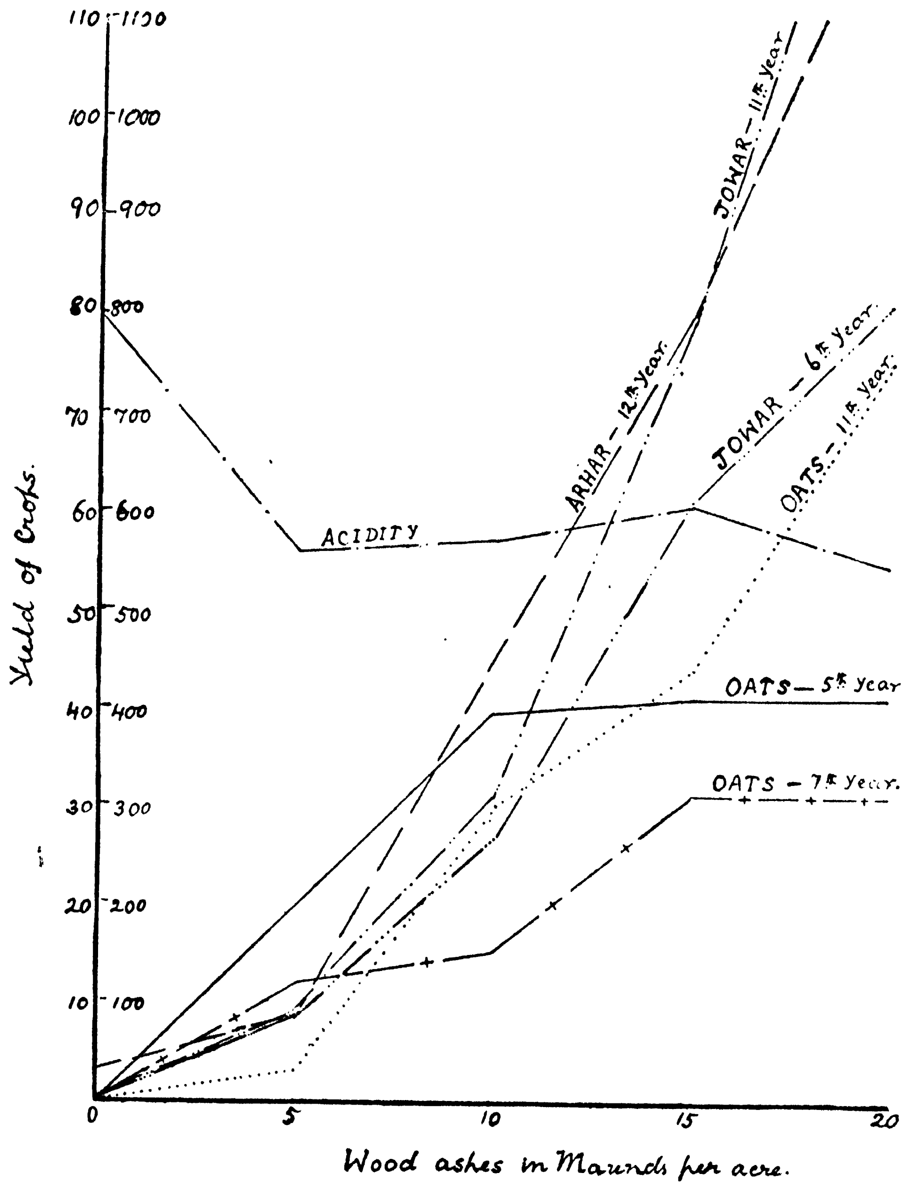

Fig. 1. Showing the effects of wood ashes and cowdung on oats, *jowar* and *arhar*. The ordinates represent the yield of crop (left) and acidity (right), while the abscissae, the amount of wood ashes applied in maunds per acre.

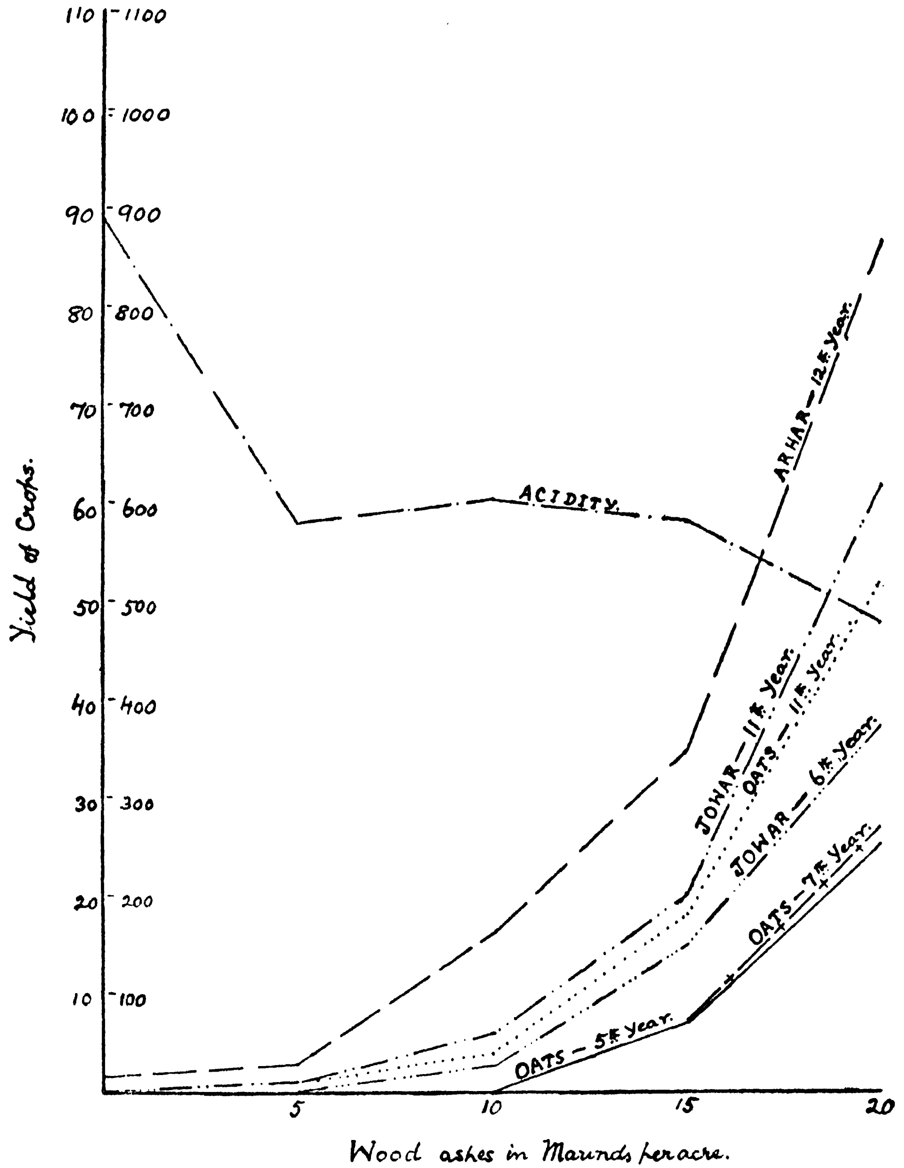

Fig. 2. Showing the effects of wood ashes alone on oats, *arhar* and *jowar*. The ordinates represent the yield of crop (left) and acidity (right), while the abscissae, the amount of wood ashes applied in maunds per acre.

On the other hand, the application of wood ashes not only decreases the acidity in the soil but allows a fairly good crop when applied with cowdung. It may also be mentioned here that cowdung acts as a nutrient plant food, but not as an

ameliorant of soil acidity. It is the application of wood ashes which furnishes the soil with both a base and a nutrient, and thus serves a dual purpose which is mostly desired in the acid soil of Jorhat.

The uncropped soil of Jorhat farm has an acidity of about 900 (parts CaO per million parts soil). When brought under cultivation such a soil will not allow the growth of *rabi* crops unless lime or wood ashes are applied. The acidity of the untreated plot is 896 and a fairly good crop is produced when this acidity is partly neutralized down to 482 by the application of 20 mds. wood ashes per acre, as is shown in Table II and the curves in Fig. 2. This evidently proves that there is a limit of tolerance for *rabi* crops towards soil acidity beyond which they do not grow well. Moreover, as the acidity decreases, the yield increases and *vice versâ*.

The relation between soil acidity and yield of crops, especially the *rabi* crops, seems to be rather definite, and it also appears that there is a certain limit of resistance for crops to soil acidity beyond which they cannot be successfully grown even with the application of a good deal of cowdung. The plots with higher acidity have produced no crop in case of oats and *jowar* and a small crop of *arhar* which can seldom be taken into account, whereas the plots with lower acidity have invariably produced the best crops in all cases.

Plants naturally prefer a more or less neutral medium. The fact that some plants do well on acid soils is no proof that they naturally prefer it to a more or less neutral one, or they would not do better on the latter type of soil. It is a question of adaptation. It is simply because they have a greater degree of tolerance towards acidity than other plants that the latter succumb and the former are finally given an undisputed field. From the results we find that oats are very sensitive to an acid medium, *jowar* comes next to it, while *arhar* grows even on an acid soil. Furthermore, we find that the yield of *arhar* in grains increases with increasing doses of wood ashes which suggests that even a plant tolerant of acidity does better on soils with lower acidity.

SUMMARY.

1. The infertility of the Jorhat farm soil with regard to certain *rabi* crops is to a certain extent due to soil acidity which in its turn leads to a general impoverishment of the soil, by removal of available plant foods in drainage water.

2. Lime is generally used as an ameliorant of soil acidity but wood ashes may be used at less cost which by their accumulative effect give excellent results when applied with cowdung. Several experiments were tried on the effect of wood ashes on various crops and, in spite of many failures, the results available were quite conclusive.

3. Besides furnishing the soil with a potash base as a nutrient carbonate, wood ashes reduce soil acidity. There seems to be a definite relation between soil acidity and crop production, especially with regard to *rabi* crops. Accordingly, crop

production is higher with the decrease and lower with the increase of acidity. Moreover, there is a limit of resistance to soil acidity beyond which the *rabi* crops do not grow.

4. The fact that *arhar* grows even on an acid soil, whereas oats and *jowar* fail, may be explained by the greater degree of tolerance that *arhar* naturally possesses towards soil acidity in comparison with oats and *jowar*.

THE EXTENT OF NATURAL CROSS-FERTILIZATION IN JOWAR (*ANDROPOGON SORGHUM*) AT SURAT.

BY

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In the improvement of any crop, the extent to which natural cross-fertilization occurs, the means by which it is brought about, and the possibility of controlling it are vital factors to be considered. They may and probably will influence the methods to be adopted and the extent to which regular or frequent replacement of seed is necessary.

Cross-fertilization may occur (1) between flowers of the same individual, (2) between individuals of the same strain, (3) between different strains of the same variety, and (4) between different varieties. Its amount in any year depends on seasonal conditions like winds, humidity and rain, on the character of the varieties and the types within them in respect to the relative time and length of the flowering period, and to the mechanism of the flower in any particular case as regards the ripening of the stigma, anthers and pollen. It also depends on the stigma length as a character of the strain or as it is affected by the conditions of growth.

The *jowars* of the Su at District generally flower in October and November at which time the wind is usually from the north. The opening of the flowers starts from 4 to 5 A.M.—the exact time depending on the previous night temperature—and continues till 9 to 10 A.M. After this time the glumes begin to close. Excluding the extreme cases of a few exceptional strains, the flowering period 'asts for nearly four weeks, each earhead requiring on an average ten days for completing its flowering. Flowering begins from the top of the earhead, and proceeds downwards in a whorl, both as regards the earheads and the individual spikes of the earhead up to a vertical length of nearly an inch per day. Assuming that fresh pollen grains are more effective than stale ones, cross-fertilization between flowers of the same region is quite likely, as the two feathery stigmas emerge earlier than the anthers. Small insects have also been observed on the earhead at the time of flowering, but the part they may play is not yet known

In *jowar* selection work at Surat, the seed used for further work is always raised from selfed seed. The whole inflorescence is bagged and thus fertilization between flowers of the same earhead is allowed, and normal setting of good viable seed is secured without any loss of vigour due to selfing. During the process of selection for fixing a type the pollen from any other individual is always excluded, while for

securing pure seed of a fixed type, cross-fertilization from sister plants of the same type may be allowed, but not from plants of any other strain or variety.

The facts presented in this note relate to my experience for two years in handling seed produced from single *covered* earheads and to the results of the year 1924-25 from an experiment specially designed for the purpose of determining the amount of natural cross-fertilization.

The method adopted in this latter inquiry has been to take plants which have bred true to certain characters for at least two generations and expose them in alternative lines to plants in which these characters are different but are equally fixed. The characters chosen for testing the extent of cross-fertilization were as follows :—

(1) Colour of midrib of leaf—white or greenish.
(2) Anther colour, after weathering—yellow, red or brown.
(3) Earhead texture—compact, semi-compact or loose.
(4) Grain colour—white, whitish yellow or yellowish.
(5) Glume character—the extent to which the seeds are covered.

With regard to some of these characters observations of importance have previously been made. It may be noted that the colour of the midrib is important, as it seems to be correlated with the sweet or pithy character of the stem. Hilson,[1] working in Madras, has observed that a white midrib means a pithy stem when the plant is in shot blade and for some time after. Further he has noted that in breeding tests the pithy character of the stem, and hence the white midrib, behaves as a simple dominant to the sweet stemmed character and hence to the green midrib. As shown later, however, this character behaves differently in different strains.

In connection with the question of anther colour, Graham [2] working at Nagpur has noted that in his experience the colour of the grain can be judged at the time of flowering, the stamens and stigmas of plants giving red grains being orange in colour and the colour in the case of types with white or yellowish grain being pale yellow. This observation, it may be noted, does not apply entirely to the *jowars* at Surat, for there exist both yellow and red anthered types with white and yellowish grain.

As regards this matter (colour of grain) and the texture of the earheads observations have been made by Kottur and Kulkarni[3] working at Dharwar, and they have used them as a means of testing the amount of cross-fertilization. Judged by the presence of earheads of intermediate texture, and brown grain colour, in the progeny of single selected earheads placed at different distances in the field, they have stated that contamination from a variety grown round the border of a field varies from nothing up to 12 per cent. according to the distance from the border.

Other observations on the extent of cross-fertilization have been made by C. R. Boll [4] in America who states that contamination between adjacent rows may

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[1] *Agri. Jour. India*, XI, pp. 154, 155.
[2] *Mem. Dept. Agri. India, Bot. Ser.*, VIII, No. 4.
[3] *Agri. Jour. India*, XVII, p. 413.
[4] Boll, C. R. *American Breeders' Association*. VI, p. 193.

be anything up to 50 per cent. Graham's figure (*loc. cit.*) varies from 0·6 to 20 per cent. Naturally the figure would vary according to the position, the nature of the variety from which contamination takes place, the distance from the source of contamination, and the prevailing environmental conditions.

Now in the first place it was desired to ascertain with regard to the midrib and anther characters above referred to as to what is the extent to which plants with these characters can be relied on to breed true when the parent earhead has been bagged and so self-fertilization secured, or when an ordinary unbagged earhead is taken from the field.

Midrib character. In 1922-23, it was found that the seed obtained from unbagged earheads on green-ribbed plants in selections of Sholapuri *jowar* bred true, while those from white-ribbed plants were variable in this respect. In certain cases they bred true ; in others they gave a ratio of white ribs to green-ribbed plants in the progeny of 5·3 or 5·4 to 1.

In 1924-25, in a selection from Chapti *jowar* in culture made with seed from bagged heads, all the plants from a green-ribbed parent bred true to this character—and this not in one but in several selections. In the case of selection 48 (from a white-ribbed parent) two out of three cultures bred true ; the third gave a ratio of white to green-ribbed plants of 2 to 1.

Anther character. In 1923-24, it was found that the seed obtained from mother earheads with red anthers either gave entirely flowers likewise with red anthers or flowers with red and yellow anthers in various proportions from 2·9 to 5·3 to 1. Where the mother plant had yellow anthers, however, the progeny bred true in this respect. This latter fact was also the case in a series of cultures made in 1924-25, when again red or brown anthered mother plants gave very variable results, red or brown anthers being 1·7 to 4·1 times more numerous than yellow anthers in the progeny.

We have thus a clear method of determining the extent of cross-fertilization by observing these characters. If seeds from strains are taken which have a green midrib and yellow anthers, the progeny will breed true to these characters unless it has been crossed with a strain with white midribs to the leaves or with red or brown anthers.

Such strains were, therefore, selected for the experiment in 1923-24, the ones chosen being " Budh-Perio 9 " and " Sholapuri I." The characteristics of each are shown in the following table—

Character	Budh-Perio 9	Sholapuri I
Midrib of leaves	Green	White
Anther colour	Yellow	Red
Earhead texture	Compact	Loose
Grain colour	Yellowish	Whitish

The strains used represented the progeny of selfed earheads and were pure as to the characters considered. The flowering time was practically identical. Two rows of Budh-Perio 9 were planted immediately to the south of several rows of Sholapuri I and the seed from each row of the former was preserved and sown. The distance between the rows was three feet, so that the first row was three feet and the second row was six feet to the south of the first line of Sholapuri *jowar*.

The result was observed in the crop of 1924-25, taking the progeny of six different plants selected at regular distance from each row and the amount of crossing judged by the number of plants with white midribs to the leaves and red or brown anther colour. The results are shown in the following table.

No. of plant	No. of plants with characters of mother	No. of plants with white midrib, red anthers, semi-compact earhead	Percentage of crossed plants
I. Row of Budh-Perio 9, three feet distance from Sholapuri I.			
1	53	15	22·0
2	66	22	25·0
3	84	13	13·4
4	64	24	27·3
5	74	15*	16·8
6	52	43	45·3
TOTAL AVERAGE	393	132	25·0
II. Row of Budh-Perio 9, *six* feet distance from Sholapuri I.			
1	72	7	8·9
2	72	7	8·9
3	60	28	31·8
4	59	29	33·0
5	50	31†	38·3
6	64	26‡	29·0
TOTAL AVERAGE .	377	128	25·0

* One of these plants had green midrib, red anthers, and semi-compact head.
† Five of these plants had green midribs, red anthers and semi-compact heads.
‡ One of these plants had green midrib, red anthers and semi-compact head.

The naturally crossed plants had their leaves with white midrib and earheads with brown anthers, the head being of a semi-compact character.[1] The anther colour was not truly red and appeared to be intermediate between that of the two parents. The grain colour was also intermediate between that of the parents.

The extent of cross-fertilization varies from 13 per cent. to 45 per cent. in the nearer row, and from 9 per cent. to 38 per cent. in the second row from the Sholapuri I type. Not a single one of the heads used as representatives (taken fairly equidistant along the rows) had been unaffected by the nearness of the contaminating type. It is curious to find that the average amount of crossing is the same in the second as in the first row (though the maximum and minimum are lower in the second row), and it suggests that some other influence than that of the wind is at work, probably insects.

In conclusion, it seems clear that under the conditions prevailing at Surat, natural cross-fertilization takes place to the extent of 25 per cent. on the average in *jowar* grown three feet apart, and that under these conditions not a single plant examined up to six feet away escaped contamination. This shows how important it is in breeding work with this crop that the original basis for multiplication should be taken from bagged plants, that seed from strains tested side by side with other types should be rejected for further multiplication, that in seed multiplication only compact blocks should be used, and that when distributed for general use, enough seed should be given out in one area at one time to ensure that practically all the planting in that area should be of the improved type.

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[1] One of the Madras workers has noted that the open-head character is dominant over the compact head—*Jour. Madras Agri. Students' Union*, XII, No. 1 (1924).

CO-OPERATIVE ORGANIZATION AND THE DEVELOPMENT OF THE SEED INDUSTRY IN DENMARK.

BY

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THE rapid development of the Danish seed industry during the past 25 years is one of the most striking features of agricultural progress in that country. At the beginning of the present century, only small quantities of different varieties of farm and garden seeds were produced. These were almost entirely used for local consumption. Now, a highly developed and commercialized industry has been built up, which, through a large home demand and an increasing export trade, contributes in no small degree to the agricultural prosperity of Denmark. The history of this development and, in particular, the important part which co-operative organizations have played in it, may be of interest to those interested in the improvement of Indian agriculture.

The seed acreage in Denmark rose from 16,500 acres in 1907 to 40,000 acres in 1912. During the Great War, this figure increased rapidly, reaching, in 1919, the total of 85,500 acres. Such an abnormal development, due to economic causes produced by the War, could not be maintained. From 1920 onwards a rapid decrease occurred due to low prices, consequent on over-production. However in 1922, the Danish seed acreage was about normal, *i.e.*, 40,000 acres, and stable conditions seem to have established themselves once more.

The climatic and general agricultural conditions of Denmark are well suited to cultivation for seed production. Large quantities of grass, root and vegetable seeds of excellent quality are produced annually. About 75 per cent. of the total seed acreage is devoted to the production of grass seeds, which are in great demand on the Continent of America and in other European countries. The development of the well-known and important dairying industry of Denmark has given considerable stimulus to the growth of improved root crops. Chiefly in response to this home demand, about 15 per cent. of the Danish seed growing acreage is under mangolds, swedes, turnips, carrots, etc. Since the War, there has been a large export of root seeds from Denmark to other countries and this is not likely to decrease. In addition, a considerable sugar-beet industry has been established and the future prospects of seed production for this crop are most favourable. A large acreage is grown for the production of seed of important vegetable and garden crops, especially cabbages, but also cauliflower, radish, spinach, garden beets, etc.

The present position of the Danish seed industry has not been reached without many temporary set-backs and without experience of periods of depression and adversity. In spite of these the industry has flourished and has become a very important branch of Danish agriculture. The present organization eminently efficient and essentially commercial as it is, could not have been developed without the close co-operation of seed growers, scientific experts, State agricultural institutions and commercial concerns. Co-operative production and co-operative distribution, combined with a realization of the value of scientific research and the practical application of scientific results in agriculture and commerce, have made possible the organization of the industry and have stabilized its position. The methods by which this has been done are no less interesting than instructive and point a definite object-lesson to agricultural co-operators in all parts of the world.

Since the early eighties, the co-operative distributive societies of Denmark had undertaken the distribution of seed and manures to their members. The demand for improved quality of seed for home consumption largely dates from the formation of the State Seed Testing Station in 1891. This institution—the history and functions of which are described later—has taken a very prominent part in the development of the Danish seed industry. In 1896, the Co-operative Wholesale Society of Denmark was formed by the amalgamation of two large associations of co-operative distributive societies. As the membership of the society was almost entirely drawn from the agricultural population, it is not surprising that the distribution of good seed was a very important item of the new wholesale society's business. To begin with, the society obtained its seed for distribution to its constituent distributive societies from the better farms and appointed seed experts to supervise and control production. Succeeding developments of this work were the purchase of a seed farm in 1904 and the renting of a large area in 1911 at Lyngby near Copenhagen. At those centres, the Co-operative Wholesale Society conducted experimental work on the improvement of farm seeds and produced specially guaranteed strains for distribution to its members. This work met with the immediate approval of the agricultural societies in the country and the farmers very quickly realized the benefit of this scientific work done under the direction of their Wholesale Co-operative Society. The result was the formation of the Danish Farmers' Co-operative Association for Seed-growing in 1906, a co-operative society of seed-growing farmers, whose combined acreage must now be almost 30 per cent. of the total seed-growing acreage of Denmark.

The aim of this association is " to promote the growing of good seeds and seed corn and to improve the method of trading between the grower and the consumer as also to form a profitable sale of good seeds at home and to foreign countries." In 1924, the writer was enabled to visit the headquarters of the D. L. F. as the Co-operative Association for Seed-growing (Danske Landboforeningers Froforsyning) is termed in Denmark—at Roskilde, near Copenhagen. At this place, are situated the offices of the association and most commodious and up-to-date warehouses and stores,

equipped with the most modern machinery for cleaning and drying all varieties of farm and garden seeds. Special winnowing and drying machines for different types of seed are installed and clean durable products of the highest grade are secured. In addition to the headquarters at Roskilde and other store-houses at different centres in the country, the D. L. F. possesses three trial farms, conducted by scientific agriculturists and specialists in seed cultivation. On these farms, the improvement of existing strains and the production of new and better strains of seed are undertaken.

The membership of the Danish Farmers' Co-operative Association for Seed-growing is confined to members of the Danish Agricultural Societies, and each new member admitted must be recommended by the Committee on Plant Culture, appointed by the association of these societies. This precaution ensures that only capable farmers can become growers to the D. L. F. The actual production of seed for the association is done by its 2,700 members, all approved seed-growing farmers. The association supplies its seed growers with selected stock seed. All the fields of seed-growing members are carefully supervised during growth by an expert staff employed by the association. The members of the association, *i.e.*, the seed growers, are on contract and have to provide a guarantee to the association of 100 kroner per hectare (2·47 acres) under seed crop. They must further bind themselves to grow only selected stock seed provided by the association, to adopt special precautions against cross-fertilization and mixture and not to grow a similar crop on any part of their land from seed obtained from other sources. The members of the association are paid for their seed on delivery at one of the warehouses, and deductions are made if, on analysis, the sample does not reach the requisite standard of purity and germinating percentage. Members are also paid a percentage on their share in the capital fund of the association which is formed by deduction of a certain percentage of the purchase price of the seed. Two per cent. of the total money received goes to a reserve fund which is paid out to members when a definite limit is reached.

The relations of the Danish Farmers' Co-operative Association for Seed-growing with other co-operative institutions and with the State, both in the production and distribution of its seed, form a most interesting study in practical and efficient co-operation. These relations are typical of the co-operative movement in Denmark and give to it no little part of that endurance and stability which are the admiration and envy of co-operative workers in other countries.

On the side of production, the agricultural societies of Denmark appoint a special control committee, known as the Inspecting Committee. This committee consists of well known experts in seed production and in the seed trade, and it has the power of directing the production of the seed-growing association and of deciding what varieties of seed should be grown after taking into consideration the requirements of the consuming trade. In addition, as mentioned above, only members of agricultural societies can become members of the D. L. F. and must be previously recommended and approved by a committee elected by the societies.

Co-operation between the Danish Farmers' Co-operative Association for Seed-growing and the State is found in a mutual assumption of responsibility for the quality of the seed for distribution. The best strains produced on the association's farms are sent to the State experimental farms for comparative cultivation tests and no seed is issued as first class by the association unless it has been classified as such by the experts at the State experimental stations. Moreover, all seed supplied by the D. L. F. is sold under a guarantee of analysis and germinating percentage, supplied by the State Seed Testing Station, and seed for export is delivered in sealed bags with such a guarantee enclosed.

On the side of distribution, the seed growers' association co-operates with the Co-operative Wholesale Society of Denmark, which in 1924 comprised 1,850 local co-operative distributive societies and " stores " with a total membership of 400,000. Through the agency of these local "stores," the improved seed, produced by the member seed growers of the Danish Farmers' Co-operative Association for Seed-growing, is distributed to farmers and small-holders all over Denmark. Thus the entire retail trade of the association is handled by the seed department of the Co-operative Wholesale Society, and a most efficient agency between producer and consumer has been organized on entirely co-operative lines. The grower is guaranteed a good and reliable market for his produce, and the farmer and member of a local co-operative distributive society can rely upon a supply of pure clean guaranteed seed of the most superior strains. In addition, the system of co-ordinated control of both the Co-operative Wholesale Society and the Co-operative Association for Seed-growing enables these institutions to regulate the acreage and output of improved farm seeds and to conduct their seed business on a thoroughly commercial basis and with the greatest possible profit and benefit to their members.

The Danish Agricultural Societies have been mentioned several times in the foregoing paragraphs, particularly with reference to the control which they exercise over the direction and management of the Danish Farmers' Co-operative Association for Seed-growing. Apart from the more commercialized co-operative undertakings in Denmark, there exist a large number of local agricultural societies in different districts of the country. These societies are maintained by members' subscriptions, donations, and State subsidies. They exercise a general supervision over agricultural and co-operative matters in their area of operations and include, within the scope of their activities, such varied subjects as the organization of live-stock shows, schemes for co-operative land improvement, field experiments and asistance to small-holders, etc. They conduct propaganda work in favour of growing improved seed and assist the seed-growing association in the control and supervision of seed growers. These societies, either singly or in groups, maintain advisory officers and experts to assist their members in agricultural matters and to bring the results of scientific research into general agricultural practice for the benefit of the farming classes. The Associated Danish Agricultural Societies is the all-Denmark organization of these local " farmers ' societies." It represents 5 provincial associa-

tions, including 137 local societies with nearly 120,000 members, and wields considerable power in the direction of agricultural policy in Denmark.

The development and expansion of the Danish seed industry and the world-wide reputation for purity and quality which is attached to Danish farm and garden seed is largely traceable to the work done by the Danish State Seed Testing Station. In 1871, average samples of grass seed from different farms in Denmark showed only 25 per cent. of pure seed able to germinate. In that year, a Seed Testing Station was founded by private enterprise and under private control. After twenty years, similarly collected samples gave 80 per cent. of good quality seed and the value of a seed testing institution was recognized and appreciated by farmers and reputable seed dealers alike. In response to public demand the Seed Testing Station was taken over by Government in 1891 and, at the present day, fully 30,000 samples of seed are tested there annually. Space does not permit of a detailed account of the system of " automatic control " which is adopted by the Danish State Seed Testing Station to ensure that the high quality of Danish grown seed for home consumption or for export is maintained. In short, seed dealers, societies and private seed growers voluntarily sign an agreement with the station, guaranteeing the purity and germinating percentage of the seed retailed by them. The State Seed Testing Station maintains a " control " by obtaining samples, either from purchasers direct or, by means of its officers, from consignments and shipments under delivery. Such samples are reanalysed and, if not found according to guarantee, compensation is paid by the seller to the purchaser, in accordance with the regulations of the station.

It is obvious that such an arrangement, however beneficial it may be to all the parties concerned, is dependent for its successful working on a very high standard of co-operation. However, about two-thirds of all the seed retailed in Denmark is under this " automatic control " by the State Seed Testing Station, including all the seed produced by the Danish Farmers' Co-operative Association for Seed-growing. The management of the Seed Testing Station is conducted by the Department of Agriculture with the assistance of an advisory board which includes farming and seed trade representatives. In no country in the world is the control of seed, used locally or exported, so carefully and so comprehensively done, and the most noteworthy feature of the system is that it has resulted, without any pressure of law, from purely voluntary co-operation of those interested.

In India, the economic uplift of the great mass of the population is intimately dependent upon the improvement of agriculture. The methods by which such improvement is introduced and established cannot be closely modelled on work done in other countries. These must be devised to suit special conditions prevailing in India and must be adapted to the needs of the country and its cultivators. The history of the development of the seed industry in Denmark illustrates—what is now generally accepted in India—that co-operation and co-operative organization is the " royal road " along which the main advance must be made. The improvement of agriculture cannot rely merely on an appeal to the larger and more in-

fluential cultivators, but depends for its fulfilment on the establishing of a desire for a higher standard of living among the masses of the rural population. This can only be induced by co-operation in the widest meaning of the term. Combination of effort, in cheapening production, in improving outturn and in raising the standard of quality and value of produce, must result in a betterment of the position of the agriculturist. The history of agriculture in Denmark is a remarkable testimony to the results achieved by co-operative organization allied to agricultural science and research. In India, though the way may be long and the difficulties great, a similar combined effort on the part of organizer and expert cannot fail to produce results which will add most considerably to the profits of agriculture and to the prosperity of those engaged in this primary industry of the country.

RIDGE CULTIVATION.*

BY

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FROM the beginning of the Surat farm in 1896 to 1920, all possible efforts by manuring, cultivation and rotation were made to increase the yield of the staple crops, but the results were found fluctuating, irrespective of the season and the treatments given. A critical study by Dr. Mann, Director of Agriculture, Bombay, Mr. Khandubhai B. Naik, the then Superintendent of the Surat farm, and the writer revealed the fact that some unknown factor overshadowed the efforts of the past experimenters. It was decided to grow cotton and *juar* (sorghum) on raised beds or ridges (Plate XX) to avoid water-logging occurring on the flat (Plate XXI), and secure thorough aeration to the roots of the growing plants. The early efforts in 1920-21 indicated the possibility of growing better crops on ridges, and showed that ridging was a most important and limiting factor towards further progress in scientific tackling of the local black cotton soils in increasing the yields of staple crops (Plate XXII). Analytical experiments to study the methods of ridging with shallow or deep intertillage, with or without manuring in different ways, gave very encouraging results on an average for the last three years. They showed an increase of 24·4 per cent. seed-cotton, and 26·8 per cent. *juar* grain, without any manuring, by ridge cultivation. The combined effect of ridging and manuring all buried in the furrow resulted in the increase of 42·6 per cent. seed-cotton, 43·3 per cent. grain and 48·6 per cent. *juar* fodder.

The question of the size of ridges can only be settled according to local requirements of the situation of the soil in the monsoon. Wherever the evil of water-logging is greater, higher (14″) and larger (5′ apart) ridges have to be prepared; and where the water-logging is partial, the lower (9″ high) and smaller (3′ apart) ridges will do. The former are costly in their initial cost, but they are permanent, lasting for four to eight seasons. The latter are temporary and much cheaper, but have to be renewed every year. Tests made in 1923 on lower and smaller ridges increased the yield by 17 per cent. as compared with 22 per cent. on higher and larger ridges. This modified method is being applied on a large scale in the Surat District—over nearly 1,300 acres in 1925—some well-to-do cultivators having purchased their own necessary implements.

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*Paper read at the Indian Science Congress, Bombay, January 1926.

METHODS OF PREPARING RIDGES.

(*a*) *Small ridges 9″ high and 3′ apart.* There are three favourable periods to prepare ridges of this size, (1) in wheat or *rabi juar* fallow lands having sufficient mulch in March-April by Middle Breakers or Middle Busters (Plate XXIII) requiring one pair of bullocks; (2) taking advantage of favourable breaks in June-July by working Middle Breakers or Busters; and (3) by inter-ridging *juar* grown 3′ apart in September-October by Middle Busters. This method is beneficial to the standing *juar* crop itself, which pays more than the extra cost of working, besides leaving the ridges useful for the next cotton crop. The interculturing between the ridges is done by the McCormick cultivator (Plate XXIII).

(*b*) To get the maximum benefit, ridges 5′ to 6′ apart and 14″ high should be prepared. This is done by ploughing the land immediately after *juar* harvest with Ransomes' Gallows plough, and then moulding the ploughed land into ridges by big Ransomes' ridgers (Plate XXIII). This operation requires usually 2 to 3 pairs of bullocks, but the cost would be reduced to Rs. 20 or so per acre by tractor-ploughing, and exposing the land for a couple of months; then discing the land and ridging the same.

The intercultivation in the case of cotton is done by a reversible disc harrow by in-throw and out-throw arrangements. During favourable breaks in June-July the reversible disc harrow by in-throw arrangements can prepare ridges 5′ broad and a foot high in three repeated operations costing Rs. 8 per acre with a single good pair of bullocks. In the case of *juar* drilled 2½′ to 3′ apart on ridges, the Middle Busters are used for late intertillage. The ridges thus made are remodelled into higher and broader ridges (making two ridges into one), simultaneously removing the stubbles and burying the manure if applied in the same operation.

The same method has a great scope of development in areas of high rainfall, where crops like cotton cannot be grown successfully at present. Again, there would be a large scope for opening up a new field in *rabi* sowings with Lister cultivation in wheat, *rabi juar*, gram, *val* (*D. lablab*), etc., in the Bhal tract of Ahmedabad, Mal tract of Kaira and Southern Surat District by application of the converse principle to take advantage of the lower sub-soil moisture hitherto lost sight of by the ordinary cultivator.

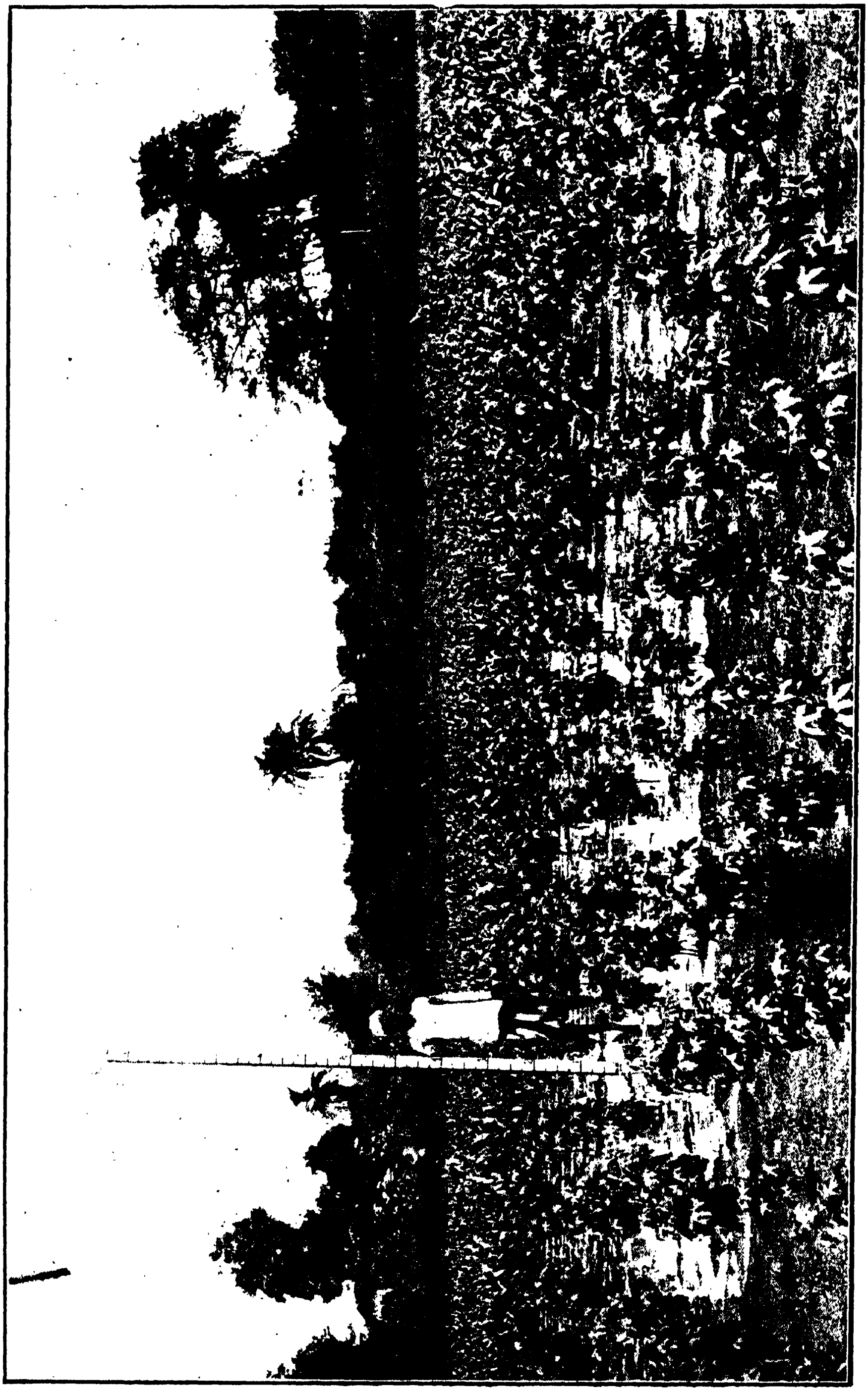
Further, the same method can be advantageously tried for the *kharif* cereal crops of North Gujarat to preserve more moisture in scanty rainfall years, by closing the ends of the furrows towards the end of the rainy season. These latter two are to be further tried before actual facts could be placed before the Congress.

DISCUSSION.

Mr. Gokhale wished to know if the enhanced crop yields from this type of cultivation in the Surat District persisted over a number of years, and if, after the land had been ridged for cotton cultivation, any improvement was noted in the following *juar* crop.

PROFUSE DRAINAGE AND STORING OF WATER IN THE FURROW AFTER 6 INCHES OF RAIN.

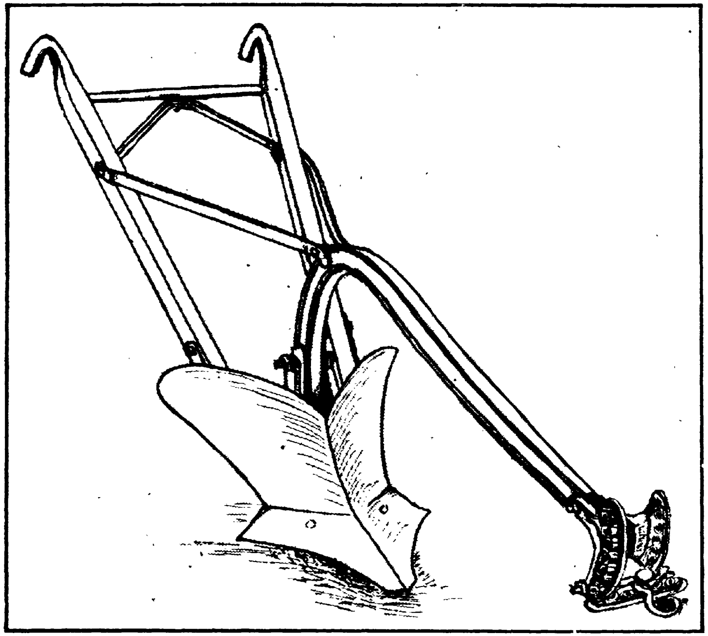
PLATE XXI.



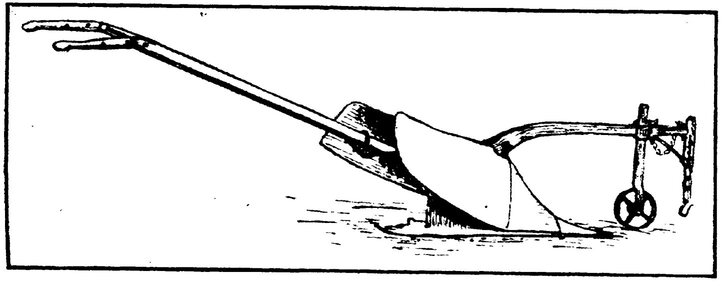
OVERSATURATION AND STAGNATION OF BLACK SOIL AFTER 6 INCHES OF RAIN.

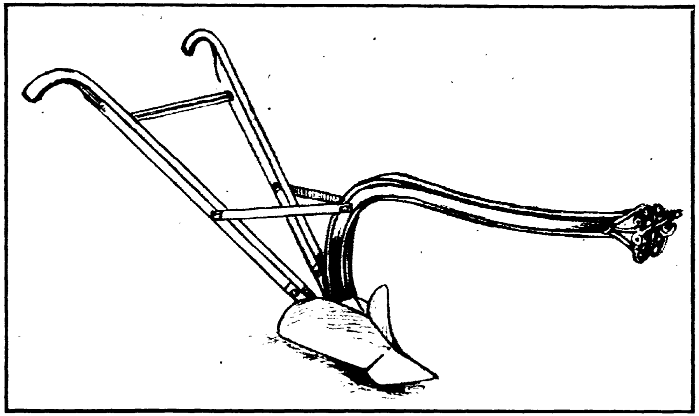
Jowar, 3′ 1′ flat. Yield of grain 952 lb. per acre.

owar, 6′ × 2′ × 1½′ ridged. Yield of grain 1,576 lb. per acre.

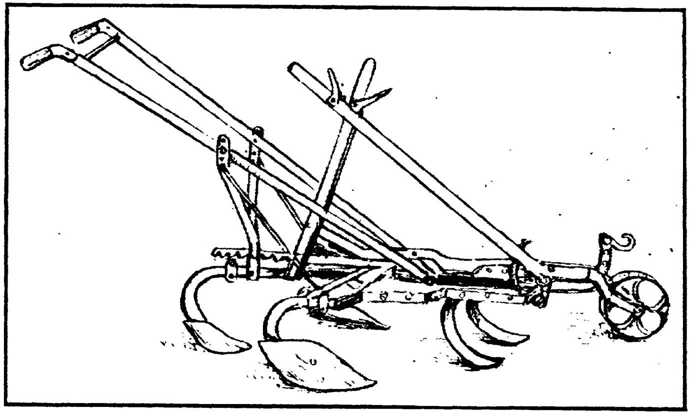


Middle Buster.





Middle Breeker.



Rao Saheb Bhimbhai answered both these questions in the affirmative. He pointed out that the ridges were repaired annually at a small cost as damage was caused by heavy rain, etc. *Juar* grown on ridges showed great root development and gave much better results than when cultivated by the ordinary local methods.

Mr. Thadani mentioned that a system of ridge cultivation for the cotton crop was in vogue in Sind but the ridges were removed by cross cultivation. He feared that more or less permanent ridges would result in inferior soil aeration.

JUTE CULTIVATION IN THE UNITED PROVINCES.

BY

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In "The Agricultural Journal of India" for November 1921, there appeared an account of some preliminary experiments on jute cultivation in the Sitapur District of the United Provinces. It now seems desirable to note on the continuation of these experiments, and to trace the progress that this crop has made towards becoming a commercial product of the district.

After the results obtained by the 1920 trials it was decided to increase the area under jute and in 1921 two maunds of seed, variety R. 85 (*C. capsularis*), was obtained from Dacca and sown by cultivators in village Samodidhi. In addition to this, 10 maunds (*C. capsularis*) and 3 maunds (*C. olitorius*) seed saved from the previous crop was also distributed by departmental agency in various villages where the crop had previously proved successful. This seed, allowing for wastage and failure, gave a total area of about 90 acres of jute.

Under arrangement with the growers a portion of the resulting crop was allowed to seed and the Fibre Expert to the Government of Bengal purchased 53 maunds 36 seers of seed for Rs. 808. The *olitorius* seed was reported as being of excellent germinating capacity and full current price was paid for it, but the *capsularis* was not so satisfactory, in some cases the germination being as low as 77 per cent. The cultivators whose seed was not taken for Dacca sold their crop as fibre in the local markets, obtaining an average price of Rs. 12 per maund for their produce.

The crop had now become better known and was becoming distinctly popular, many enquiries and requests for seed being received, and in 1922 the area again increased. Fourteen maunds of seed were distributed by the department, two maunds of which was fresh seed obtained from the Fibre Expert. In addition to this, many cultivators had kept their own seed from the previous crop which they resowed. During the rains of this year very bad floods were experienced in some parts of the *ganjar* tract and the ordinary *kharif* crops were nearly a total loss. The jute crop also suffered to some extent, but the early sown *capsularis* stood up well and in October was practically the only crop surviving in these flooded areas. Nine maunds of seed was again sent to Dacca from this crop and fetched Rs. 162 but the same complaint of low germination was again received.

In 1923, owing to its success during the floods of the previous year, the demand for seed greatly increased and many enquiries regarding the cultivation of the crop

were received from zemindars and cultivators of the adjoining districts of Kheri, Bara Banki and Bahraich, where conditions are to some extent similar to those obtaining in the Sitapur District. Thirteen and a half maunds Dacca and 25 maunds departmental seed were distributed, the cultivation being carried out as far as possible under our supervision. It is known that 864 separate cultivators grew the crop during this season.

During 1924, the area again increased and was estimated at 940 acres and the Deputy Commissioners of Sitapur and Kheri Districts very kindly gave orders that in future the area under this crop should be noted by Patwaris; the figures thus obtained should prove valuable in estimating the spread and distribution of its growth. In 1925, the area in Sitapur and Kheri Districts was 1,800 acres sown from seed distributed through Government agencies. The real area under this crop was, I have no doubt, in excess of this, owing to zemindars and cultivators retaining seed for sowing from previous crops.

Up to 1924, except during the first year of the original experiment when the fibre produced was sent to Calcutta jute mills for examination and report, the cultivators had been selling their fibre in the local markets and had obtained a very fair price, but the crop having passed the experimental stage and having obtained a real footing, it became of primary importance to endeavour to establish a permanent market where they might obtain a price more in accordance with the real value of their produce.

It was not possible for several reasons to continue the purchase and despatch to Bengal under departmental arrangements of the fibre produced, so during August 1923 the Fibre Expert to the Government of Bengal visited the jute area in company with the Director of Agriculture, United Provinces, and myself with the object of seeing the crop *in situ* and of discussing the question of the establishment of a market. Unfortunately owing to very heavy rains and floods we were unable to penetrate into the real *ganjar* area and were only able to see some jute crops on the *uparhar* or higher land on the west bank of the Sarda river which were not of the best.

With the co-operation of the Fibre Expert, however, endeavours were made to induce a firm of Bengal jute brokers to send an agent up to the district to purchase the crop and pay the cultivators for their produce on the spot. This arrangement, unfortunately, did not materialize and the position remained as before, the cultivators selling their crop as fibre in the local markets. Owing to the spread of jute cultivation the fibre was, however, becoming well known in these markets, and the average price per maund obtained in 10 of such markets was Rs. 14-12 and Rs. 12-4 in 1923 and 1924, respectively, while sann-hemp fibre was fetching about Re. 1 to Rs. 1-8 per maund less. In 1925, it is estimated that 13,000 maunds of jute came in, the bulk of which was purchased by agents of various Bengal jute concerns. On a representation from these agents I have arranged with the railway company concerned for preferential rates under certain conditions, for the carriage of jute fibre from Lakhimpur to Howrah. The original difficulty of obtaining a satisfactory

market would seem, therefore, to have been solved, provided that the area of jute sown and the quality of fibre produced can be maintained.

SUMMARY.

As a result of the careful preliminary experiments carried out it was proved that this crop is suited to the special conditions that obtain in the *ganjar* tract of the United Provinces, and subsequent experience has borne out the fact that if careful attention is paid to the selection of suitable land, and care taken with the preliminary cultivation and growth of the crop, particularly in its early stages, very fair crops of jute can be produced. It has also been shown that in the *ganjar*, provided the crop is sown early while sufficient moisture remains in the soil to give it a good start, irrigation is not necessary. Yields of over 25 maunds per acre have been obtained under these conditions. In the *uparhar* tracts jute sown on the rains gives quite a satisfactory yield but the produce is not equal to that known in the *ganjar*.

The area has increased from 90 acres in 1921 to 1,800 acres in 1925, and this has been brought about largely on the crop's own merits and popularity with the cultivators, it having been impossible for the department to make widespread efforts to increase its cultivation owing to the reduction of the specially trained jute staff obtained from Bengal and also owing to certain diffidence on my own part to encourage the extensive cultivation of a crop the produce of which might have to be disposed of at unfavourable rates.

As was pointed out in the preliminary note on this subject, if this crop is to become a commercial produce great attention will have to be paid to educating the cultivator to market a high grade of produce, as the margin between inferior and good quality jute is very considerable, but to do this extra financial aid will be necessary for the employment of wholetime specialists to tour extensively in the jute areas to instruct the individual cultivators.

In conclusion, it may be said that provided arrangements can be made for satisfactory sale of the produce, and at present it would appear that there is no difficulty in disposing of jute fibre locally at remunerative prices, there is no reason why jute cultivation should not rapidly extend and why the growth of this crop should not be of considerable benefit to the cultivators of the *ganjar* area, where owing to floods the growing of ordinary *kharif* crops is precarious.

I have again to acknowledge the help afforded to the department by Mr. W. C. G. Dunne, M.B.E., Special Manager, Court of Wards, who has rendered every assistance in popularizing this crop, and also that of the Revenue staffs of Sitapur and Kheri Districts, and finally that of the district agricultural staff who have been in direct charge of all field work.

SELECTED ARTICLES

INVESTIGATIONS IN AGRICULTURAL SCIENCE AT ROTHAMSTED.

BY

SIR EDWARD JOHN RUSSELL, O.B.E., D.Sc., F.R.S.,

Director, Rothamsted Experimental Station.

THE Rothamsted experiments began and grew up in typically British fashion. They were started by John Bennet Lawes 83 years ago on his own land and at his own cost for the purpose of showing him how plants grow. They were planned so well and made so thoroughly that they yielded much wider information than was expected. The information was freely given to farmers who, in return, in the year 1855—long before the days of agricultural education—subscribed to build a laboratory in which the necessary scientific work could be done. This was the first scientific laboratory to be built by public subscription (Plate XXIV, fig. 1). To the end of the century Lawes and his colleague Gilbert worked together, the longest scientific partnership in history, always at the sole expense of Lawes—in conformity with the ideas of private enterprise and self-help held by the great Victorians : repeating the same field experiments year after year because they continued to give fresh information. Finally before his death, Lawes set up a Trust which he endowed with £100,000 to carry on the work in perpetuity. Lawes and Gilbert have been dead for more than 25 years, but the work still continues without change of tradition, purpose or policy : the changes in the Trust Committee have been few and infrequent ; indeed, one of the original members, Professor H. E. Armstrong, is still with us ; there have been in the whole 83 years only two directors before my appointment.

No other agricultural experiment station in the world has so long a history possessing so many unique features. The unchanging tradition of the place is that all the work shall be of the highest attainable standard ; that the smallest decimal point shall be as trustworthy as it can be made. The long experience of the station shows that trustworthy work is always valuable ; we are repeatedly, even to-day,

*Paper read at the Royal Society of Arts. Reprinted from *Jour. Roy. Soc. Arts*, No. 3824.

using figures obtained 60 or 70 years ago and still finding them helpful. The purpose of the work has always been to obtain knowledge; knowledge of plants and soils, rather than to show farmers how to obtain more money. This too is justified by events, for the knowledge is permanent and helps the farmer in all conditions, while the practical advice must change continuously from farm to farm and from year to year. Finally, the policy has always been to put the information obtained in such form that students, teachers, experts and leading agriculturists could use it as a foundation on which to build up the particular recommendations to be made to farmers to meet the particular conditions of the time.

All this remains, and let us hope always will remain, unchanged. But the work has altered and expanded enormously; it is carried on by a staff of 40 vigorous able scientific workers and an equal number of competent assistants; the laboratories have been entirely rebuilt in recent years on a much enlarged scale. The station has far outstripped its original resources, and now, in accordance with the spirit of the age, it receives substantial state aid through the Development Fund and Research Funds, administered by the enlightened and sympathetic staffs of the Development Commission and the Ministry of Agriculture. The attitude of the farmers is as sympathetic as ever, and the chief agricultural bodies, the Royal Agricultural Society, the National Farmers' Union, the Central Landowners' Association, the Central Chamber of Agriculture, the Farmers' Club, Workers' Unions, and other organizations all recognize the imperative necessity for scientific research as the basis of agricultural education.

The first achievement of Rothamsted was the discovery that certain simple salts already known or thought to be plant foods could be used on the farm to increase farm crops. Before that time farmyard manure had been the recognized manure; it is of course highly efficient, but can never be obtained in large quantities; the output of human food from the farm was limited by the supplies of farmyard manure. After the discovery of artificial fertilizers the yields rose; wheat increased from 20 to 30 bushels per acre. Wages were low and prices high; crop production was profitable. Then came the great changes of 40 years ago, when transport developed and the exploitation of the vast virgin regions of the world began. Food was poured into this country at prices with which our farmers could not compete; the idea of safe-guarding or sheltering the industry was not entertained, and agriculture suffered terribly. There emerged, by the cruel process of elimination, the result that the farmer should produce only those things for which his land was well suited and for which his markets were good; farming, in short, became a study in adaptation; finding out what crops would grow best, eliminating those that would not grow well and concentrating on those that would. The adaptation is never perfect in Nature; something has to be done to the soil to make it suit the plant, and something to the plant also to make it a little more suitable to the soil. The better the plant fits the soil the better is the chance of success, and the aim of the scientific agriculturist is to get a perfect fit.

Fig. 1. The first scientific laboratory built by farmers. Rothamsted Laboratory, 1855–1914.

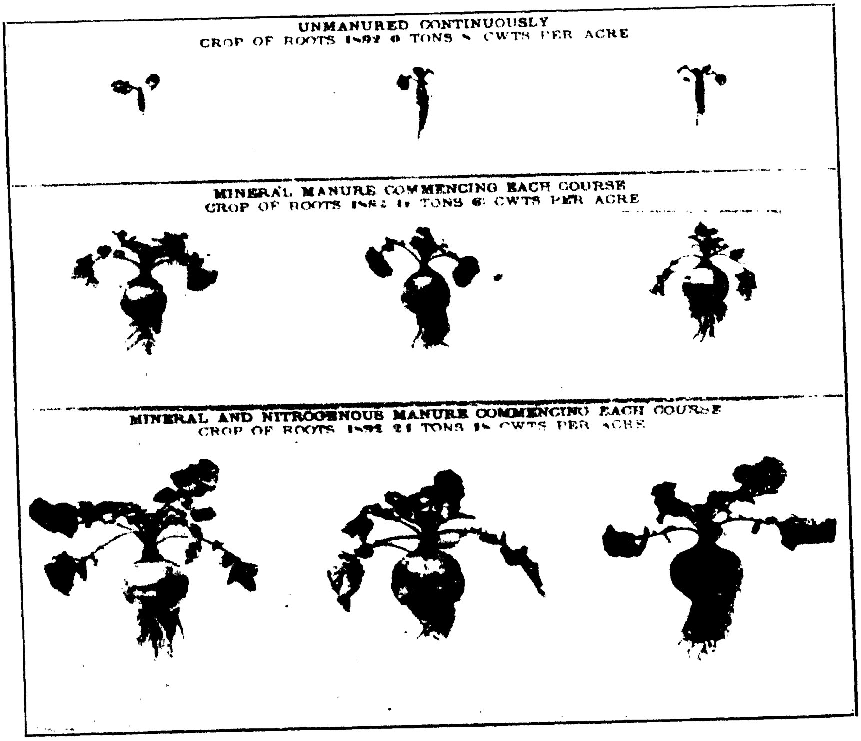


Fig. 2. Lawes and Gilbert's experiments with swedes. Upper row, no manure; middle row, mineral manure, including superphosphate; bottom row, nitrogenous manure in addition.

The Rothamsted workers study the methods of altering the soil and of effecting minor changes, fine adjustments, so to speak, in the plant; the first business of producing a range of plants suited to different soils and climatic conditions being done by plant breeders elsewhere.

One of the simplest means of improving the soil for the growth of crops is to add manures, farmyard manure or a mixture of artificial manures. The manured plant is larger than the unmanured, and so the yield increases. But it is not a photographic enlargement; there is always some distortion. Nitrogen compounds enlarge the leaves and stems more than the roots; phosphates enlarge the roots more than the leaves. This is shown in Plate XXIV, fig. 2 where an unmanured swede is compared with others manured respectively with phosphate and nitrogen *plus* phosphate. The relative weights of the plants when the unmanured is put at 100 are :—

	No manure	Super-phosphate	No nitrogen	Super. + nitrogen compounds
Leaves	100	183	100	191
Roots	100	324	100	150

All crops are of course dependent on their leaves, and most crops, with the general exception of the leguminosæ, to which I shall refer later, respond to nitrogenous manure. But for some crops abundant leaf growth is especially important, therefore they always receive nitrogenous fertilizers, *e.g.*, crops grown entirely for their leaves: including fodder crops such as cabbage, kale, hay, green rye, etc.; or crops which, though not used for their leaves, make heavy demands on them, *e.g.*, potatoes and mangolds.

The Rothamsted experiments have brought out the interesting fact that there is curiously little variation in the effect of nitrogenous fertilizers from year to year. The average increases from the use of sulphate of ammonia are given in Table 1; results of the same order, for some crops larger, could no doubt be obtained by nitrate of soda or nitrate of lime in equivalent amounts. Within limits it does not much matter whether one starts from a low or from a relatively high level; the action has thus something of an "additive" nature. About 40 or 50 per cent. of the nitrogen is utilized and the rest on present methods is lost. This loss of nitrogen is one of the serious problems still before the investigator. The effect of a second cwt. of sulphate of ammonia is sometimes equal to, sometimes less, and sometimes greater than the first, but the effect of a third cwt. is less though it may still be profitable; the Law of Diminishing Returns, has, however, set in.

TABLE I.

Increased crop yields obtained by the use of 1 cwt. sulphate of ammonia per acre.

		1922 Rothamsted	1923 Rothamsted	1924 Rothamsted	Outside centres	Average of all soils and seasons to 1920
Wheat	bu.	3·25	..	..	4·3—6	4·5
Barley	,,	5·5	4·5	8·16	3·5	6·5
Oats	,,	..	8·3	..	..	7
Potatoes	cwt.	20	22—25	20	..	20
Swedes	,,	20	25	5—9	30	20 N. country 10 S. country

The special effect of phosphates in encouraging root development is of obvious advantage for crops grown mainly or entirely for their roots, *e.g.*, swedes and turnips ; but it also has an advantage whenever the roots are likely to have difficulty in growing, *e.g.*, on heavy soils, in cold districts, backward seasons, conditions where spring droughts are common, which will dry up the plant unless its roots have already struck sufficiently deeply into the soil.

Along with the stimulation of root development there is also a stimulation of tillering and a general acceleration of plant development continuing right up to maturation—whether this is one action or several is not known. The effect is so marked that in high lying arable districts, such as the Wolds, superphosphate is often given to cereal crops expressly for the purpose of hastening the ripening and bringing in the harvest some days earlier than otherwise. The effect can also be utilized to help the plant avoid certain pests. The gout fly of barley (*Chlorops tæniopus*) lays its eggs early in the season at the tip of the leaf. The larvæ hatch out and crawl downwards ; if the young seed head is still in its ensheathing leaves the larvæ enter and feed upon it. But if the seed head has been stimulated to push out even a few days earlier it is safe, because the larvæ only crawl downwards and never up the stem (Plate XXV, fig. 1).

The special effect of potassic fertilizers is to enhance the health and vigour of the plant which is specially important where growth is being artificially stimulated. Any lack of potassium is followed by loss of vigour or disease, whether one is dealing with tomatoes, fruit trees or farm crops, grass, mangolds, potatoes. Mangolds grown without manure are small but healthy. Addition of nitrogenous and phosphatic manures without potassium increases the crop, but at the cost of its health, and when large quantities are given the crop becomes unhealthy and inefficient as a sugar producer. But addition of potassic fertilizer at once restores health and efficiency and leads to a great increase in sugar production. Potatoes behave in

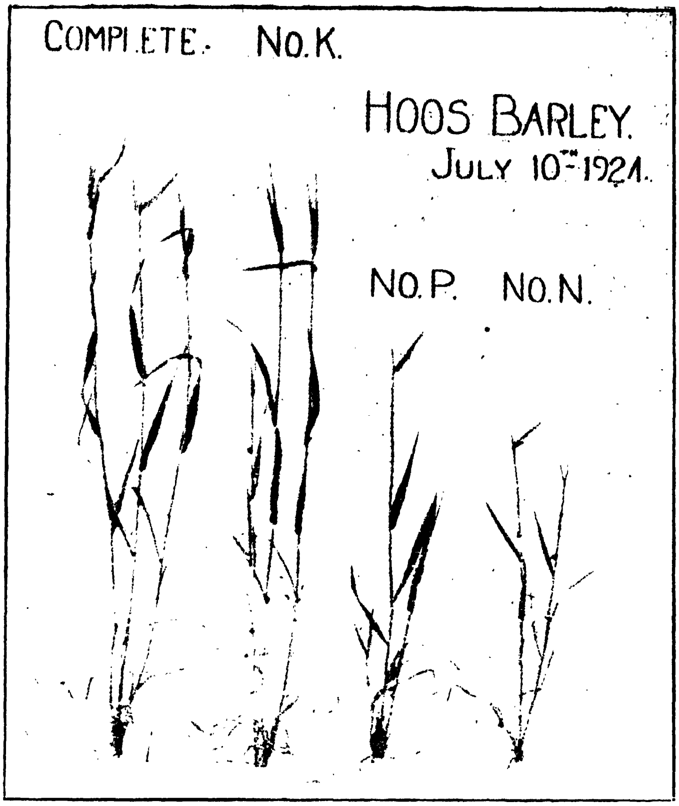


Fig. 1. Effect of fertilizers on the development of the barley plant. Without phosphate, tillering and maturation are both delayed.

Fig. 1. Broadbalk wheat field. The old method of laying out an experiment; single plots, not duplicated.

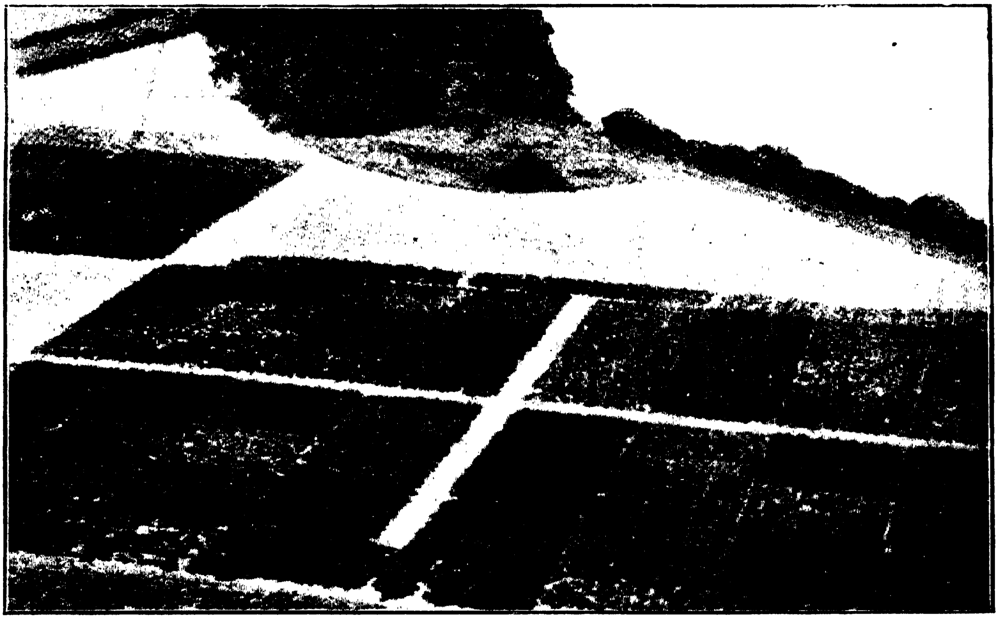
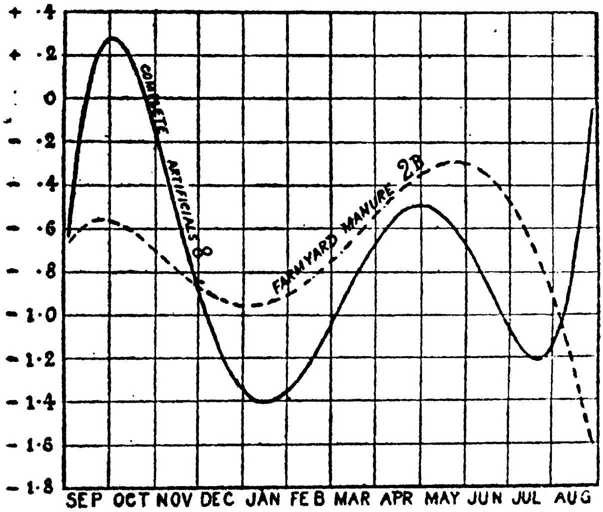


Fig. 2. Modern field experiments; potatoes. Plots laid out in a Latin square, fully replicated.

like manner, and the facts here are of such great technical importance that they have been worked out in considerable detail so as to help the farmer in his choice of the various potassic fertilizers obtainable : the percentage of starch in the potato and the amount of starch produced per acre are both increased by potassium (Plate XXV, fig. 2).

These effects of the fertilizers are modified by other conditions, for the plant is very plastic and easily altered by soil factors and by weather. A scheme good in one season may be useless in another, and, until the effect of soil and weather on fertilizer action is known, it is impossible to give definite advice to farmers. Special methods are required for this investigation, because one cannot produce an experimental season ; you have to accept what comes and then deduce the actions from the results. It is the supreme advantage of the Rothamsted field experiments that they have gone on so long. During their 70 or 80 years the rainfall has been measured throughout, and temperature, sunshine and other factors for a considerable time. The relationship of the seasonal factors to plant growth and fertilizer action is studied by modern statistical methods. The effects are of two kinds. Some are produced before the seed is sown ; others appear only after the plant is up, but their intensity differs with the method of treatment. These points are illustrated by the curves showing the effects of varying rainfall on the yield of wheat (Text-figure). The

AVERAGE EFFECT IN BUSHELS PER ACRE OF ONE ADDITIONAL INCH OF RAIN (BROADBALK WHEAT).



Influence of rainfall on the yield of wheat; after October the effect is depressing, but it varies with the month and manuring.

effect of rainfall is considerably modified by the method of manuring, and there is reason to hope that schemes of manuring could be worked out suitable for given rainfall conditions.

The introduction of statistical methods for studying the field data constitutes one of the new developments at Rothamsted which we believe will have far-reaching consequences. For it not only ensures that the field data shall be thoroughly explored to extract as much information as they will yield. Statistical methods also enable the experimenter to improve his experiments and make his results more trustworthy ; they even go further and enable him to calculate the probable value of his data. The old field plots which gave the first information about artificial fertilizers are not very accurate ; they cannot measure differences of less than 10 or 15 per cent., nor can their trustworthiness be readily calculated. In the first development of a subject when nothing is known, rough methods are often very useful. But as knowledge grows these methods become unsuitable, the scientific workers and the farmer both need greater accuracy than 10 or 15 per cent., the farmer because his margins of profit are cut very finely.

The modern methods of field experiment worked out at Rothamsted are capable of revealing differences of the order of 2 per cent. Some of the potato experiments are shown in Fig. 2 on Plate XXVI ; these contrast with the older method shown in Fig. 1 on the same Plate.

These general principles hold for all farm crops with the important exception of the leguminous crops. Instead of starving when they receive no nitrogen they flourish quite well. This was a great perplexity to Lawes and Gilbert, who exhausted the resources of agricultural chemistry in trying to explain it ; they failed for the reason that has stopped the progress of many other practical problems ; because science was not far enough advanced. The answer came when the science of bacteriology developed and showed that leguminous plants do not live by themselves, but in partnership with bacteria in nodules on their roots, and the secret of the successful growth of leguminous crops lies in the successful working of the partnership between the crop and the bacteria.

The early workers isolated the bacteria from the plant and grew them in quantity, with the idea of adding them to the soil or the seed in readiness for the young plant. The idea was sound and the operation sometimes worked admirably, especially in laboratory tests, but it had a disconcerting habit of breaking down, and so the practical man in England would have none of it. It was more successful in Scandinavia.

Investigations at Rothamstead showed that the British failures arose from three or four causes : (1) something might be lacking which the plant needed and then, of course, no addition of micro-organisms would help matters ; (2) some of the soils were acid, on these neither organisms nor plants flourish ; (3) sometimes the organisms died on the way to the farm. These various defects were put right, and a discovery was then made which added considerably to the success of the operation. The organism passes through a life-cycle in the soil ; in some of the stages it can move about, in others it cannot. The rate of movement is not more than 1 inch in 24 hours, but this is quite enough to make the difference between success and failure. Inoculation succeeds only when the organisms can travel to the young

roots. The bacteriological workers found that phosphates and a little milk make the organisms mobile, and so these were introduced into the process. It is now much more effective and is giving good results.

The partnership between the organism and the plant is mutually advantageous. The organism fixes gaseous nitrogen and changes it into a complex nitrogen compound—a change no chemist can effect or even understand– then passes this compound on to the plant. In return the plant supplies the organism with sugar, the great motive power in the reaction ; the fixation of nitrogen, however it is done, requiring considerable energy which has to be obtained by the oxidation of something. Directly the organism gets into the root the plant sends out a network of conducting vessels from its main circulatory system to surround the colony of organisms, carrying sugar to them and drawing off the nitrogen compounds. These vessels are, therefore, the conduit pipes connecting the organisms and the plant and making the partnership effective.

A remarkable discovery was made at Rothamsted about this connecting system. The pipes are not formed unless a trace of boron is present ; only a minute quantity is needed, larger quantities injuring the plant. How it acts is a mystery ; no substitute is tolerated, the plant will have boron and nothing else. If boron is not given the conducting system is not formed, the organisms can neither obtain sugar nor give up the nitrogen compounds they have produced ; they therefore feed on the root and become harmful parasites instead of useful partners.

This close relationship between plants and organisms turns up repeatedly in agriculture. It is now known that the process of making plant food in natural soil is brought about by micro-organisms which feed upon dead plant residues and break them down into the simple foods of plants. They are being closely studied at Rothamsted ; time does not allow an adequate discussion of the results, but there are two other directions in which a practical application is being sought.

It has always been known that farmyard manure is a highly effective fertilizer. It was for a time rather neglected by agricultural chemists, who were dazzled by the striking effects produced by artificial fertilizers in the flush of the first great triumph for agricultural chemistry. But experience has shown that artificial fertilizers are insufficient in themselves to maintain fertility permanently ; farmyard manure or other material of like nature, *i.e.*, bulky plant residues, is needed. For farmyard manure not only provides a complete food for plants– the only complete food at present known—but it also improves the soil. But farmyard manure is not in itself the food of plants ; it becomes plant food only after it has been broken down in the soil. Now this breaking down is done by micro-organisms, and the question arises whether micro-organisms could not do the whole process of making farmyard manure from straw as well as decomposing it in the soil. Experiment showed that they can ; if the organisms are given enough water and nitrogenous food and are not injured by acidity, they make a very useful manure out of straw or other vegetable refuse which otherwise would have but little value. The method

is being applied on the large scale by the Adco syndicate, a non-profit-making body financed by the public spirited action of Lord Elveden.

A third application of the knowledge of micro-organisms is made at present chiefly in glass houses. The population of a glass house soil is very mixed and not all helpful to the plant. On the whole the harmful organisms are more easily killed than the beneficial ones, and so a process of heating or poisoning the soil has the paradoxical effect of improving its fertility. Certain benzene derivatives are very promising. The work is being developed at Rothamsted in the laboratory for the study of insecticides, because it is found that certain closely allied substances are effective insecticides, and there seems to be fore-shadowed the possibility of a new industry in making substances to control soil organisms and insect pests.

So far we have devoted our attention entirely to the feeding of the crop. There remains the more difficult problem of the cultivation of the soil. Long generations of farmers have evolved a highly efficient art of cultivation, while generations of village smiths, and afterwards their successors the engineers, have developed tools and implements for doing the work. But the whole thing is empirical ; there is as yet no scientific basis for either farmer or engineer to work on ; and in consequence there is the risk that the work is not being done as well or as cheaply as it might.

Cultivation is simply moving the soil, but the result is to collect the fine particles into crumbs and this not only brings the soil into good condition for root development, but improves the moisture and air relationships of the soil.

The mechanical part of the process—the moving of the soil—involves three distinct actions ; cutting the soil, sliding the tool over or through the soil ; and lifting the soil to turn it over. The processes are all capable of physical investigation. The first step is to measure the total action by a dynamometer recording the draw bar pull between the tractor and the implement. The measurements are complicated by the fact that the soil even in one and the same field is variable, some parts of the field being much more resistant than others. Statistical examination of the data is therefore always necessary. The amount of the pull depends on the constitution of the soil ; partly on the visible mineral particles but mainly on the minutest particles, the clay, which have marked colloidal properties. Colloids are much modified by electrolytes and by other colloids ; a striking example is seen in the reduction in draw bar pull brought about by the addition of lime and colloidal organic matter, *i.e.*, decayed farmyard manure or plant residues.

Extended analyses of the dynamometer records and of the physical properties of the soil are necessary before it is possible to disentangle the parts played by friction, cohesion, plasticity and mechanical work, but the task is capable of precise execution. The further step of discovering how the soil crumbs are formed and how and why their formation should improve the moisture and air relationships of the soil, necessitates studies of surface forces and colloidal properties, which, while lengthy, are within the ambit of a well-equipped physical department.

One of the first fruits of the physical investigation has been the discovery of a simple means whereby the resistance of the soil to the plough could be reduced. The soil colloids are electronegative ; if therefore a negatively charged plate is inserted in the soil the water will pass out from the colloid and become deposited on the plate. Now a film of water is an almost perfect lubricant ; if, therefore, the ploughshare is kept negatively charged, it becomes coated with a film of water, and therefore continuously lubricated so that it moves through the soil with less resistance than before. The maintenance of an electric charge is not in principle difficult : it necessitates taking current from the tractor drawing the plough.

The farmer is not dealing with soil alone, but with soil plus water ; the soil remains the same but the water varies considerably from week to week according to the rainfall. All these properties therefore have to be studied in reference to the quantity of water present in the soil.

The cutting through the soil—in other words its cohesion—becomes less and less as the water increases ; if this were the only factor in cultivation the wetter the soil the better ; but the friction on the other hand becomes greater and greater as the water increases ; if this were the only factor concerned the drier the soil the better. For each soil there is a certain range of moisture content when cultivation is most easy, neither cohesion nor friction being too great. Further, over this range, variations in moisture content, while they greatly alter the cohesion and the friction, do not appreciably alter the labour of cultivation, the loss on one property being made up by gains on another.

The end result is not new ; good ploughmen know it already and have practised it for generations ; they have learnt by long experience the happy mean content of water within which the soil can be cultivated and they do not attempt cultivation when the soil is too dry or too wet. But the analysis and explanation of the fact could not before be given.

This experience happens over and over again whenever an art is being reduced to a science. Harrowing the soil gives a further illustration. Its object is to break the soil lumps to pieces and get them finally down to grains. The scientific worker shows that as a lump of soil dries it shrinks, first by the exact volume of the water lost, afterwards by less than this volume. When the dried soil is rewetted it expands, but it expands more than it shrank. The phenomenon is common among colloids and is called hysteresis : it admits of a simple explanation, because the original wet lump contained no air in its innermost crevices, while the dry soil does contain air ; on rewetting, the original air is still imprisoned and helps to expand the lump of soil. It follows that a soil containing a given amount of moisture may occur in two states ; the down grade or the up grade, and in the up grade it is expanding more with increasing moisture than in the down grade because of the imprisoned air, and it is therefore more unstable and easily shattered. In order to get the best effect from harrowing, the farmer should allow the soil to dry beyond the point where harrowing would be effective, and should then wait for the rain to rewet the soil up to this point before

he harrows. The facts are clearly ascertained and the deduction perfectly sound and of great practical value. But once again the art of the practical man has forestalled the science of the laboratory and the farmer knows this already.

It might be asked : if the farmer knows these things, and if the effect of scientific workers is but to obscure what seems a simple empirical fact by enshrouding it in involved explanations, why strive to change the ancient and effective art of husbandry into a difficult if not incomprehensible science ? The answer is simple : the farmer cannot cultivate without implements ; for these he has to go to the engineer. The engineer to have his chance must be given not only a clear cut problem, but also curves and quantitative data of this very kind. In the past he has had to do without this help and make an implement as best he can to the descriptions (you cannot call them " specifications ") of the artist in cultivation. And so it comes about that a great multitude of implements has been laboriously evolved by the costly process of trial and error, whereas with the exact knowledge of the work to be done they could have been designed for maximum effectiveness.

We come back, then, to our starting point, that the prime function of an experiment station is to obtain knowledge, precise and well founded, and to express this knowledge in a form in which experts can use it.

COTTON IMPROVEMENT LAWS IN CALIFORNIA.*

BY

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CONDITIONS are favourable for cotton in the irrigated valleys of California and Arizona, including the better qualities of fibre. In view of the higher costs of production, it has not appeared that a cotton industry could be maintained on a basis of direct competition with the eastern Cotton Belt in raising ordinary short staples. The Pima variety of Egyptian cotton is grown in Arizona, while most of the cotton in California is of an Upland variety called Acala, introduced from Southern Mexico.

The growing of short staple Upland cottons has been profitable in California in seasons of high prices, but the need of producing uniform, high quality fibre has been recognized by the growers, in order to stabilize the market relations. The reasons for standardizing the production of cotton are the same that have been recognized with other crops in California, and similar methods are being followed, through co-operative organizations of the growers.

The production of miscellaneous, mongrelized cotton is wasteful, and the commercial classification of the bales is a difficult and costly operation, with results that do not satisfy either the farmer or the manufacturer. Many of the commercial difficulties are reduced or avoided through standardized production, so that all of the bales contain the same kind of cotton. The sampling, grading and stapling of the individual bales may prove unnecessary in districts where production is standardized.

Cotton is grown as an annual crop, and production can be standardized only by establishing and maintaining adequate supplies of pure seed, which is possible only in communities that restrict themselves to one variety.

The Coachella Valley in Riverside County was the first community to adopt the Acala cotton in 1920. The seed-stocks were maintained in isolated districts, and other varieties gradually eliminated. The same course is being followed in several other valleys. The advantages of standardized production of cotton are clearly understood and the stage of legal recognition and protection of such communities has been reached. The Legislature of California recently has enacted

* Reprinted from *Jour. of Heredity*, XVI, No. 9.

two laws in behalf of the cotton industry, one to stabilize the pure seed districts, where only a single variety of cotton may be grown, and another providing for the certification of pure cotton seed by the California Department of Agriculture.

The Acala variety is a superior type of Upland cotton, discovered in 1906 in Southern Mexico by the U. S. Department of Agriculture, acclimatized in Texas, and grown on a large scale in Texas and Oklahoma, to the extent of the supplies. It is an early, productive variety, with large, " storm-proof " bolls, well adapted for easy and clean picking. A bale per acre is considered as a normal yield in California and two-bale yields are not infrequent in some of the irrigated valleys. The fibre is abundant and of excellent quality, with a length of $1\frac{1}{8}$ or $1\frac{1}{16}$ inches under favourable conditions, and generally commands a premium over the shorter staples. In addition to uniformity, strength, and good spinning qualities, a special characteristic is reported from England and France, in taking dyes better than most cottons of the same staple.

The following statement regarding the community law is from the Official Record of the U. S. Department of Agriculture for August 5, 1925. Also the text of the law will be of interest to cotton breeders and to those who are concerned with the problem of pure seed supplies.

Legal protection of cotton communities in California.

That the farmers of each community restrict themselves to the planting of a single variety has been urged by the Department of Agriculture as an essential step in the progress of the American cotton industry. The advantages in community production are now so well recognized in California that legal protection is being given to the one-variety communities against the danger of mixture and impairment of the seed-stocks by careless or irresponsible individuals.

In two of the California cotton-growing counties, Riverside and Kern, ordinances were passed by the boards of supervisors to keep other kinds of cotton seed from being planted in the one-variety communities. At the last meeting of the State Legislature an Act was passed which definitely excludes other varieties of cotton from specified districts where the farmers have restricted themselves to the Acala variety.

The purpose of the enactment to protect the public interest in the improvement of the cotton industry, is clearly stated in the first section of the Act (California Assembly Bill No. 167), and is regarded by the framers of the Act as in line with well-established precedents. It is recognized in other public improvements that the responsibilities are to be shared by the entire community that establishes the improvement, as in irrigation or drainage districts. No extra cost is involved in establishing the one-variety improvement, but only the requirement that growers refrain from injuring their neighbours who have adopted an improved system of production. The cotton land becomes more valuable in a restricted community

because it can be used with greater advantage to the farmer, as in parts of California where a definite exclusion of noxious weeds or diseases is being maintained.

As compared with the usual conditions of mixed-variety production each individual farmer of a one-variety community is able to raise more cotton and cotton of better quality, which can be sold at a higher price. The manufacturers are willing to pay more for dependable supplies of uniform fibre because the spinning and weaving are less expensive and the resulting fabrics are better. The advantages to be expected eventually through establishing and maintaining a system of community production and marketing of the crop of Acala cotton in the single-variety communities may be estimated conservatively at from 3 to 10 cents per pound, or from $15 to $50 per bale, more than the growers would receive if other varieties were admitted and the usual mixing and mongrelizing of the seed stocks took place.

Under the usual conditions of production, with different varieties grown in neighbouring fields and the seed mixed together at the public gins, most of the crop is produced from mongrelized, " gin-run " seed and the lint is of irregular, inferior quality. On account of cross-pollination by insects and the construction of the gin machinery the mixing and deterioration of seed stocks is practically inevitable if different varieties are grown in the same community. No general utilization of superior varieties is practicable without the one-variety communities where the pure planting seed can be produced in sufficient quantities to maintain the quality of the cotton throughout that region.

The protection of one-variety communities is of interest in other States not only as a step in working out the general problems of the cotton industry, but as assuring a source of seed supply of good varieties that may be drawn upon in emergency years. Twice in the last 10 years most of the good stocks of planting seed have been lost over wide regions of the eastern Cotton Belt, as a result of unfavourable weather and excessive weevil damage, so that most of the crop of the following years had to be planted with inferior seed, for lack of any supply of good seed in sufficient quantity.

TEXT OF ONE-VARIETY LAW.

An Act to provide for the growing of one variety or species of cotton, to wit, Acala, in certain prescribed and defined districts in the State of California ; to prohibit the picking or harvesting of any variety or species of cotton other than that known as Acala in such districts ; to prohibit the possession within such districts for the purpose of planting any seeds or plants of any variety or species of cotton other than that known as Acala in such districts ; to prohibit the ginning of any variety or species of cotton other than that known as Acala in such districts ; defining such districts ; and fixing the penalty for a violation of this Act.

The people of the State of California do enact as follows :

Section 1. The legislature hereby declares that the purposes of this Act are to promote, encourage, aid, and protect the planting and growing of cotton in the

State of California; that it believes this purpose best can be accomplished by restricting within certain areas hereafter defined the planting and growing of but one variety or species of cotton, to wit: Acala; that by this means alone is it possible to bring the cotton-growing industry in the State to its highest possible development and to insure the growing of the most superior and economically most profitable variety or species of cotton; that the planting of pure seed is essential to the production of a more merchantable and better grade of cotton and cotton seed and for the production of a grade of fibre best suited for manufacturing purposes; that the planting of impure seed or plants other than that permitted in the areas hereinafter defined is an economical harm and loss to the planter thereof and an irreparable injury to the adjoining or neighbouring growers; that the restriction of the use to which cotton lands may be used, as provided in this Act, is essential to the highest development of the cotton-growing industry and of benefit even to one who would violate the provisions of this Act; that it is essential that but one variety of cotton should be ginned in the district in this Act defined, otherwise the gin will mix the different kinds of seed, crossing takes place in the fields, the varieties are mongrelized, and cease to be uniform, the fibre deteriorates in quality, and the seed rendered unfit for planting; that solely by restricting the growing of one variety or species of cotton in certain areas can the fibre be grown of uniform length and quality, and the highest price paid for the cotton thus obtained, and the production of fibre of different lengths or grades be prevented; that fibres of different lengths and grades are commercially inferior and when assembled in one lot or grade or classed and given the value of the lowest grade in the lot or sample; that Acala cotton is now the variety or species of cotton that has been most highly developed and improved and most suited commercially for growing in the districts in this Act defined; that if future experiments should develop an improved variety or species of cotton, this Bill can be amended to designate it; and that the districts in this Act defined can be altered, restricted or extended.

Section 2. This Act shall be so interpreted and construed as not to be considered the taking of private property without due process of law; nor disturbing the owner in the control or use of his land for lawful purposes; nor restricting his right to dispose thereof, but as a declaration by the legislature that its use for the purposes herein forbidden is prejudicial to the public interests and an economical loss to the State and an irreparable loss and injury to the cotton growers.

Section 3. In the districts in this Act defined, it shall be unlawful to plant any seeds or plants of any variety or species of cotton other than the seeds or plants of that variety or species known as Acala.

Section 4. It shall be unlawful in the districts in this Act defined to pick or harvest cotton of any variety or species other than that known as Acala.

Section 5. It shall be unlawful for any person, individual, copartnership, association, firm or corporation, or agent or employee thereof, to have in his or its possession within the districts in this Act defined for the purpose of planting any

seeds or plants of any variety or species of cotton other than that known as Acala.

Section 6. It shall be unlawful for any gin located or operating in any one of the districts in this Act defined to gin any variety or species of cotton other than that known as Acala.

Section 7. District number one shall consist of the county of Riverside; district number two shall consist of the county of Kern; district number three shall consist of the county of Madera; district number four shall consist of the county of Fresno; district number five shall consist of the county of Kings; district number six shall consist of the county of Tulare; district number seven shall consist of the county of Merced; district number eight shall consist of the county of Stanislaus; district number nine shall consist of the county of San Joaquin.

Section 8. Any person, individual, copartnership, association, firm, corporation, agent or employee who or which shall violate any of the provisions of this Act shall be deemed guilty of a misdemeanour, and, in addition thereto, shall be liable in a civil action for all damages that may be occasioned or caused by a violation of this Act.

Section 9. If any clause, sentence, paragraph or part of this Act shall, for any reason, be adjudged by any court of competent jurisdiction to be invalid, such judgment shall not affect, impair, or invalidate the remainder thereof, but shall be confined in its operation to the clause, sentence, paragraph, or part thereof directly involved in the controversy in which such judgment shall have been rendered. The legislature hereby declares that it would have passed this Act irrespective of the fact that any clause, sentence, paragraph or part thereof be declared unconstitutional.

Section 10. That this Act shall not apply to the planting or growing of cotton in the experimental stations or farms conducted by the United States Government; the State of California; nor to the transportation of seed or plants by interstate or intrastate commerce, nor to seed in transit from a point without one of the districts in this Act defined to a destination without such district; nor to the transportation of plants or seeds into one of the districts hereinafter defined for experimental or technical purposes by the United States Department of Agriculture, the Department of Agriculture of the State of California.

Section 11. All Acts and parts of Acts in conflict herewith are hereby repealed.

FIXING THE TIME OF THE CANE HARVEST.*

METHODS EMPLOYED IN JAVA TO ENABLE CUTTING TO COINCIDE WITH THE PERIOD OF OPTIMUM SUGAR CONTENT.

BY

SUT NI QUAR.

The problem of harvesting cane at the time of optimum ripeness is an exceedingly difficult one, as a large number of factors are involved and these are not always controllable. If the factory is small, operation must be begun before the cane is ripe, or must end with deteriorated cane; if transport facilities are inadequate, the same situation exists; if tops must be had for planting the next crop, it may become necessary to cut a certain field earlier than is desirable; if a field is distantly located or difficult of access, the harvesting may proceed more slowly than the ripening of the cane. There is no need to mention further difficulties of this sort, as many of them are inherent in the situation peculiar to a given enterprise, to which no general solution applies. In what follows, therefore, I shall confine myself to a discussion of how the time of optimum ripeness of a given field is determined in Java. The figures obtained by the so-called preliminary analyses form the basis for determining the most suitable time for beginning the harvest, independently of the several factors above cited.

HOW THE CANE RIPENS.

The sugarcane begins to ripen from below. The lower end, which is partly under ground, ripens first, while the top is the last to attain complete ripeness. But before this point is reached the lower part has already passed the peak of ripeness and has begun to lose saccharose through transformation into glucose.

Now the lower part of the cane stalk is much heavier than the upper part. These two factors, together with the relation between the rendements of the different parts, form the basis for judging the moment when the cane can be harvested to best advantage. It is not sufficient merely to know the quality of the juice in the different parts of the stalk; we must know also the respective quantities. A retrogression in purity quotient of the lower end of the stalk is not always compensated by an equally great improvement in the quotient of the upper end; on the contrary, such a condition may mean a greater or smaller loss. Formerly,

* Reprinted from *Facts about Sugar*, XX, No. 50.

it was the custom in Java to cut the stalks into ten pieces for testing, but this made so much work that the more practical method of dividing them into three equal parts has been adopted, a method which guarantees a sufficient degree of accuracy.

Testing stalks by sections.

To obtain an insight into the ripening of a given field the procedure adopted is as follows :

In arbitrarily selected plots in the field—the plots being as regularly spaced as possible—eight stalks are picked out and tagged each with a label, on which are noted the name of the field, the variety of cane, together with a letter (the letter depending on the number of samples) and a number which may run up to and include 8. Every ten days a sample is brought in, comprising all stalks in a certain series. Each stalk is cut into three parts ; each part is separately pressed and the juice analyzed ; from the pressing the rendement is determined. The course of the ripening can be followed by means of a graph. As soon as the rendement lines of the lower and middle parts touch each other or come very close together, it may be assumed that the optimum time of harvest is at hand. If the field is allowed to stand longer the lower end begins to lose sugar. The upper end may be gaining sugar, but since the lower end is the heavier the loss in this end is soon larger than the gain in the upper end. This can be shown further by separately calculating a curve from the stalk or sap weights of the three parts whereby are shown the real amounts of recoverable sugar per part which gives a still closer insight into what is going on in the cane plants. It should be remembered, however, that the cane weight is variable and fluctuates to a greater extent than the rendement.

The sugarcane being a living organism, it is, like other things that breathe, difficult to bring within the range of our calculations and graphs, and quite often it mocks the most meticulous calculations of the scientific experts. It is indispensable, therefore, that some other means of control also be employed. This is chiefly a matter of visual inspection, which can best be done by the field employés who have cared for the cane during its period of growth. These employés are familiar with all the circumstances which have affected the cane during its life.

Influence of soils.

To further particularize the method, a given field is divided, if necessary, into a certain number of parts of not too small extent ; for example, into complexes of three to four bouws (1 bouw $= 1\frac{3}{4}$ acres), preferably according to differences in the composition of the soil, with further regard to the requirement that the time of planting in a given complex shall not include a period greater than 14 days. From each of these parts a sample is taken for analysis as above described. If the field comprises three different soil types, such as heavy clay, light clay, and sandy soil, it is correspondingly divided into three complexes, the boundaries of which corres-

pond as closely as possible with the lines of the soil types. It is to be expected, and practical experience has shown the expectation to be just, that the cane on heavy clay ground will close its period of growth before that planted in light sandy ground, and will, therefore, sooner reach the point of optimum sugar content. On light ground during the rainy season following the monsoon, the cane grows much more slowly than on heavy clay, which is more or less compacted by the rains with the consequence that the roots of the cane partially die and there is less chance of after-growth than in gravelly soil, which remains loose.

Even between clay soils of the same type there may be variations in the time required for complete ripening, such differences being due to different situations in the area—as, for example, where one part of the field is continually inundated during the wet season, while another part may not be affected by such a circumstance. This is merely one indication of the many factors which may have an influence on the ripening, and it will therefore be clear that a knowledge of these factors and their influence on each portion of the field must be taken into consideration along with the course of the ripening as shown by the analyses in order to arrive at the least possible loss of sugar in the field.

Variable factors influence results.

Even when the analyses and the determination of the most favourable moment for the harvest have been given the greatest possible exactness, it frequently happens that the rendement actually obtained from the field does not coincide with that of the latest ripeness analysis. The determination of the real rendement of a given field or of a given variety is a matter of very great difficulty. Not all varieties have the same juice content; in other words, the recoverable sugar as shown by the analysis cannot be multiplied by the same factor for all varieties. The ratio of the pressing factors of the different varieties must be accurately known from practical data, something which has not yet been attained. Stalks of a single variety planted on different soils and in different parts of a field do not all have the same pressing factor. It is naturally not possible, when on a given day several different varieties are received from different fields, to determine the pressing factor for all of the special cases. For this reason nearly all Java factories assume for 15-day periods a factor for each variety, irrespective of the fields from which the cane comes, and at the end of the 15-day period this factor is corrected according to the results actually obtained in the mill. At the end of the campaign a general correction is applied to the factor, if necessary. While by this means it is possible to keep the errors low, they are by no means entirely eliminated.

It is possible to abolish these errors entirely, but to attain this it is necessary to have the rail emplacements so arranged that all lorries from a given field, loaded with a given variety of cane, can be placed on the same track so that the cane on these lorries can be ground in succession. In the factory things are so managed

that before beginning to grind the cane from a given field, the mills are allowed to run empty for a moment in order to make a separation from the juice from the preceding field. The correct pressing figure thus becomes known and it is possible to make much closer calculations of what each variety produces in any given field. It thus becomes a question of planning, which has the great advantage that not only the old varieties but also the new ones can be quickly and accurately judged as to their true values.

Deterioration loss after cutting.

It is also true that although the cane has been harvested at the right moment a considerable loss may still occur if it is not ground within 48 hours, as has already been remarked. It is not alone necessary that the transport be so organized that at a given moment a larger than normal quantity of cane can be transported, but the grinding capacity of the mill must be sufficiently elastic so that grinding can be speeded up to keep pace with a quickened ripening of the cane so as to avoid being forced to start grinding before the cane is fully ripe at the beginning of the campaign or to cut dead cane at the end. From the figures of the previous year each factory can easily ascertain how great is the maximum capacity it is able to reach.

That the loss which occurs whenever the time elapsing between cutting and grinding is too long is of serious moment appears from the fact that even 48 hours after cutting the purity falls three to four degrees and the rendement on the cane is one-half of one per cent. lower, which, on a production of 14,000 piculs per bouw, means a loss of seven piculs of sugar, or 544 pounds per English acre. It is to be further borne in mind that the loss that occurs in the first 48 hours is progressive and is further increased when the cut cane is exposed to the sun, something which in the tropics is scarcely avoidable.

NOTES

VILLAGE POULTRY INDUSTRY OF ETAH, UNITED PROVINCES.

FOR the past six years the writer has had the interesting task of judging at the annual poultry shows held in Etah, and she is deeply impressed with the results of six years' organized efforts accomplished by Mr. Slater and his wife in the village reconstruction work they are so devotedly carrying out. More should be known of this work both in order that it may be copied elsewhere and also so that it should receive the full support that it requires and deserves from the public.

In 1920, the Mission Farm at Etah was struggling for its existence as regards its poultry work in the villages. The aftermath of the war left its mark here as everywhere else. The poultry show held that year attracted only some 100 village birds and but few villagers attended. The United Provinces Poultry Association that year gave Mr. Slater 100 pure bred pedigree cocks from the Lucknow farm to place in villages, and other friends gave funds for the distribution of pure bred eggs for the same purpose. The U. P. Government also assisted with small grants of money. These efforts have borne great fruits. From that year onwards each annual poultry show has grown in numbers, until the problem is now how to provide accommodation and arrange for the number of exhibits and the villagers who accompany them.

For example, this year (1926), 1,010 exhibits were staged, consisting of 312 pure bred Leghorns, 344 Minorcas, 226 cross-bred fowls, 61 exhibits of lots of six eggs and 67 other varieties. This last item was of birds shown by local important residents who have also got interested in poultry. The total exhibits this year exceed by several hundred birds the show of 1925.

What is also so remarkable from a judge's point of view, is the steady improvement in quality ; so much so, that I have volunteered to be financially responsible for the expenses of taking 20 exhibits in Leghorn and Minorca birds from Etah villages to compete side by side with other exhibits at the next All-India Show, Calcutta. The birds will there meet in open competition and, I feel convinced, will hold their own.

The Etah Poultry Show has attained the popularity of a *mela*, and in co-operation with a small Agricultural and Industrial Exhibition makes a brave show, occupying many shamianas and tents. Villagers from all over the district come in with their birds, and the poor and depressed classes for whom this work is being done look far from being depressed or poor. They are sturdy, well fed, independent people, wearing decent clean clothing that carries the stamp of prosperity. No wonder, for besides the income that comes from keeping better fowls the clever

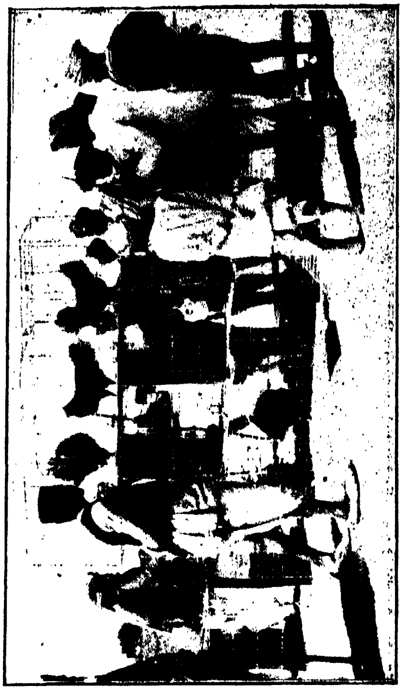
Etah Poultry Show, showing prosperous appearance of depressed classes of Etah villages.

Etah Poultry Show: all tents being full, other birds penned out in the open.

Villagers bringing in exhibits.

Village eggs from pure bred Leghorn and Minorca fowls.

Mrs. Fawkes judging.



First prize winning birds.

village poultry-man can win money in prizes besides useful awards in the shape of brass household utensils inscribed with the wins they have merited. All this entails generous money support, and I can assure Government and all those interested in the welfare of the peasantry that no money can be better spent than in helping this growing industry. Plates XXVII and XXVIII illustrate better than words the results I have attempted to record. [MRS. A. K. FAWKES.]

Since writing the above I hear that a cloud burst of rain recently deluged the Etah farm and caused severe losses in chicken. I trust support will be forthcoming so that there should be no check in such valuable enterprise. [A. K. F.]

REFRIGERATION AS A MEANS OF PRESERVING MANGOES AND OTHER TROPICAL FRUITS.

THE use of cold storage as a means of preserving fruit and vegetables is known in most parts of the world, but it has, except in the case of bananas, not been applied extensively for the preservation of the usual tropical fruits, and particularly of the mango. And yet there are few cases in which, if applicable at all, it would be of great value. Many of the tropical fruits, and again particularly the mango, become ripe in a very restricted period, and a period when there is a glut in the market and a correspondingly low price, is rapidly followed each year by a time when there are no fruits to get and the price is very high.

Though much information is available as to the conditions under which semi-tropical fruits can best be kept in cold storage, yet few data are available in connection with the fruits dealt with in the present paper. As regards the mango, one authority[1] states that he was able to preserve the fruit for 31 days at 34° to 40° F., and another[2] reports that experiments in shipping mangoes from Australia at a temperature of 35° F. were satisfactory.

The experiments recorded in the present paper were made at the cold store in the Crawford Market, Bombay. The range of fluctuation of temperature in this cold store is much greater than is desirable, but is unavoidable when it has to be frequently opened to bring in and take out materials kept on a commercial scale. The records have been made during the three seasons of 1923, 1924 and 1925.

Mango. Two varieties of mangoes were used in the experiments, namely, *Alphonso* and *Pairi*, two of the best types in India. The former keeps much better than the latter, but, for both, a steady temperature of 39° F. to 40° F. was found suitable. At this temperature, mature and green Alphonso mangoes can be kept for a month without deterioration. Tightly packed fruit wrapped in tissue paper kept longer and better than loosely packed and unwrapped fruit. This suggests

[1] Higgins. The Mango in Hawaii. *Hawaii Agri. Expt. St. Bull.* 12, 1906.
[2] Collins. The Mango in Porto Rico. *U. S. Dept. Agri., Bureau of Plant Industry, Bull.* 28.

that even a somewhat higher temperature than that named would suit the fruit quite well. As a matter of fact a rise in temperature to any point between 40° and 50° F. did no harm to the stored fruit.

A sudden fall in the temperature below 36° F. told at once seriously on the fruit. The skin became immediately spotted, in the form of small scattered depressions all over the skin of the fruit. When the temperature was reduced to 25° F. the skin of the fruit was softened, but the damage did not go further when the temperature was raised above 40° F. and ranged between 45° F. and 50° F.

A sudden fall in the temperature did not affect the pulp of the fruit nearly so much as the appearance of the skin. Spotted fruits, in fact, when taken out of store after 20 days, ripened well from within, and the taste was almost as good as that of fresh fruits. The low temperature affects ripe or half-ripened fruits more seriously than green mangoes.

Green Alphonso mangoes which had been in the cold store between 36° to 40° F. for a month took six days to ripen after withdrawal, and kept good for ten days further. These were exceedingly attractive in colour, as good, in fact, as naturally ripened mangoes.

Chiku (*Achras sapota*) *or Sapodilla plum.* This fruit, which is a great favourite in Bombay, when green, resists temperatures below 40° F. better than any of the others tested. The skin does not become pitted like that of the mango by a low temperature. Frequent fluctuations, however, below 40° F. make the fruit very hard and it ripens very unevenly when removed from cold storage. Between 40 and 50° F., green *chikus* could be kept for a month, and then ripen normally when removed from the cold store.

Banana. Green bananas of the principal varieties cultivated round Bombay--*Rajapuri*, *Sonkel*, and *Red Bassein*--could be kept without change of colour at a steady and uniform temperature of 40° F. and could be normally ripened after removal from cold storage.

Fluctuations in the temperature below 40° F. affected the green fruits and gave them a smoky colour. The yellow and ripened fruits became softer and darker. When the temperature fluctuated between 40° and 50° F, the bananas, either green or ripe, were not affected.

Ripe but firm fruits were also successfully kept at a steady temperature of 45° F., but the skin became darker in colour. Ripe bananas when wrapped in paper showed their original freshness on removal from the cold store, but unwrapped fruits lost their lustre and became dull.

Green bananas kept in the thawing room, with a temperature ranging between 55° F. to 60° F., changed colour from green to greenish yellow within seven days. These greenish yellow bananas kept quite well in the cold store at 40° F. to 43° F. for 15 days with repeated (three times) fall of temperature to 30° F. and equally gradual rise again to 42° F. The colour of the skin was, however, darkened by this treatment.

Papaya. The papaya fruit does not seem to keep well under the conditions of temperature available in the cold store. It remained good for a fortnight at temperatures above 40° F., but on removal from the store, it did not ripen evenly, and the ripened fruit presented firm flesh in places while in other parts the papaya was soft. The colour of the flesh was quite similar to that ripened in the ordinary way outside the store. [G. S. CHEEMA and S. R. GANDHI.]

PRODUCTION OF REFINED SUGAR FROM GUR IN INDIA DURING THE SEASON 1924-25.

THERE were 29 *gur* refineries in India in the year 1924-25, but out of these 16 did not work during the season for the reasons mentioned below. Of the 13 refineries which worked during the season and submitted their returns, 6 were situated in the United Provinces, 5 in Madras and 2 in the Punjab. It may be mentioned that none of the refineries situated in North Bihar, where the sugar manufacturing industry is concentrated, worked during the season.

We give below figures of *gur* melted, sugar made, and molasses obtained therefrom in the refineries situated in (1) The United Provinces and (2) The Madras Presidency and the Punjab, and also consolidated figures for the whole of India during the two seasons 1924-25 and 1923-24.

	1924-25 Maunds	1923-24 Maunds
(i) The United Provinces—		
Gur melted	1,204,762	1,755,114
Sugar made	541,638	816,097
Molasses obtained	511,265	752,616
(ii) Madras Presidency and the Punjab—		
Gur melted	658,480	1,059,746
Sugar made	374,483	506,623
Molasses obtained	213,014	394,902
(iii) Whole of India—		
Gur melted	1,863,242	3,274,606*
Sugar made	916,121	1,538,304*
Molasses obtained	724,279	1,329,498*

* These totals include the figures for Bihar where 6 refineries worked in the season 1923-24.

The season was unfavourable for the refining industry as there was an appreciable reduction in the acreage under cane and in the production of *gur* in India in 1924-25 as compared with the previous season as shown below :—

	Area in acres	Yield in tons
1923-24	2,920,000	3,317,000
1924-25	2,532,000	2,537,000

In the United Provinces, which produces the largest quantity of refining *gur* in India, there was a marked drop in the outturn of *gur* amounting to approximately 600,000 tons. The result was that the price for this commodity ruled high, while the tendency for the price of foreign refined sugar was downward (Table I). The refineries thus found that it did not pay to manufacture refined sugar out of *gur* at the prevailing prices for these commodities.

TABLE I.

PERIOD	Average price per maund of refining *gur* at Siswa Bazar (principal market for this material in Gorakhpur District)	Average price per maund of refined sugar (Java White) at Calcutta
	Rs. A. P.	Rs. A. P.
December 1924	5 5 0	12 9 9
January 1925	5 9 0	12 8 0
February ,, ...	6 0 6	12 6 6
March ,, ...	6 8 9	12 3 0
April ,, ...	6 6 0	12 7 9
May ,, ...	6 10 0	11 11 9
(*Gur* market closed thereafter.)		

A note published in the March (1926) Number of this Journal gives the total quantity of sugar produced by factories making sugar direct from cane for the two seasons 1924-25 and 1923-24 as follows :—

1924-25	920,305 maunds or	33,745 tons
1923-24	1,044,856 ,,	38,312 ,,

If the quantity of refined sugar produced in India by modern refineries be added to these figures, the total production by modern factories and refineries would amount to 1,836,426 maunds or 67,336 tons in the season 1924-25 as compared with 2,583,160 maunds or 94,718 tons in the previous season.

As the production of *gur* in the season 1925-26 is estimated by the Statistical Department at 375,000 tons more than last year and as the price for this commodity is also lower (Table II), enquiries were made whether any of the refineries which remained idle in the season 1924-25 would start working this year. The replies received show that 18 are treating *gur* this year (*i.e.*, season 1925-26) as against 13 last year.

TABLE II.

PERIOD	Average price per maund of refining *gur* at Siswa Bazar (principal market for this material in Gorakhpur District)	Average price per maund of refined sugar (Java White) at Calcutta
	Rs. A. P.	Rs. A. P.
December 1925	3 12 9	10 8 9
January 1926	3 14 6	10 15 6
February "	4 3 6	11 7 9
March "	4 5 0	11 5 6
April "	4 8 0	11 10 3

In conclusion, we have to express our obligations to the managing agents and proprietors of various refineries for the readiness with which they furnished us with the statistics worked up in this note. [KASANJI D. NAIK.]

WORLD'S POULTRY CONGRESS, OTTAWA, CANADA, 1927.

THE Third World's Poultry Congress will be held in the city of Ottawa from 27th July to 4th August, 1927, under the presidency of Mr. Edward Brown, F.L.S., of London. His Excellency the Governor-General Baron Byng of Vimy has consented to act as the Chief Patron. Invitations have been issued to practically all foreign countries and all sections of the British Empire, and the Congress promises to be the largest international gathering which has taken place in Canada. A poultry exhibition will be held in connection with the Congress, and it is anticipated that among the exhibitors will be Their Royal Highnesses the Prince of Wales, the Queen of Spain and the Queen of the Belgians.

All correspondence regarding the Congress is to be addressed to the Secretary, Ernest Rhoades, Experimental Farm, Ottawa.

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

CULTURE OF COTTON SORE-SHIN FUNGUS.

THE fungus *Rhizoctonia solani*, which is responsible for the "sore-shin" disease of cotton seedlings, was induced to produce its fertile stage *Corticium vagum* under experimental conditions. A marked variation in culture was observed between the strains from Egyptian cotton and some of those from other countries when grown under identical conditions. Strains from India, England and United States of America were used and the best medium for all was found to be steamed potato. The differences between some of these strains were retained throughout the experiments and affected the microscopic characters of the cultures, rate of growth at different temperatures and virulence on certain hosts. Differences in the microscopic characters were less clearly defined. The author regards all the isolations studied by him as strains of *R. solani*. [*Rev. Appl. Mycology*, 1925, **4**, 130 : from *Trans. Brit. Mycol. Soc.*, 1924, **9**, 200-210. H. R. BRITON-JONES.]

VARIETY TESTS WITH COTTON IN EGYPT (STATE DOMAINS).

THE crop yields of varietal trials in the State Domains for the years 1916 to 1921 are subjected to statistical interpretation. Variety chequer plots with six repetitions per feddan provide an arrangement insufficiently critical for testing cotton, which responds markedly to small variations of environment. On this plan, variations under 8·7 per cent. in yield are not significant. An increase in the number of repetitions, the standardizing of rotations, measured waterings and other precautions to assure uniformity in treatment are thought admirable. [*Min. Agri. Egypt, Techn. Sci. Ser. Bull.* 51, pp. 16. TREVOR TROUGHT.]

APPLICATION OF SODIUM SILICOFLUORIDE.

Some experiments have been made on the toxicity of sodium and potassium silicofluorides, and other related compounds, as stomach poisons for insects when used in the form of spray fluids. The results are in general agreement with those of Macrovitch who used the sodium compound in the form of dust, and support the view that this substance has interesting possibilities as an insec-

ticide. Some data are given and it is stated that the toxicity was slightly, but probably not significantly, less when 1 per cent. of saponin was added to the spray fluid. The foliage of the hazel twigs, which was sprayed with very fine suspensions of the silicofluorides in water, was uninjured. [*Ind. Eng. Chem.*, 1925, **17**, 323. F. TATTERSFIELD and C. T. GIMINGHAM.]

DESCRIPTION OF HUMIDITY RECORDERS.

An account is given of the equipment at the Weather Bureau of the United States, with brief notes on the history of the instruments. These include wet and dry bulb psychrometers (with machine and hand whirling types), Lamprecht's and Marvin's hair hygrometers, and a hair hydrograph. [*Jour. Opt. Soc. America*, 1925, **10**, 352-359. ROY N. COVERT.

PINK BOLLWORM LARVA IN EGYPT.

In Egypt the pink bollworm passes from one cotton season to the next mainly as a full-fed larva in a small cocoon of silk, usually spun between two cotton seeds, one of which has been eaten out by the larva. When buried in the ground, the death rate of the larvæ increases from the surface downwards ; at 30 cm. none survives. The death rate is more rapid if the land is kept moist, especially by heavy watering every two weeks. The larvæ die very rapidly in berseem, the usual rotation crop. They survive a little longer in wheat, whilst in fallow several live till the next crop. [*Min. Agri. Egypt, Techn. Sci. Serv. Bull.* 58, pp. 7. C. B. WILLIAMS and IBRAHIM EFF. BISHARA.]

CULTIVATION OF SEA ISLAND COTTON.

Observations on spacing suggest that plants should be spaced as close as is compatible with proper access to light ; and that vegetative branches may be suppressed by drilling and deferred thinning until from five to six weeks after seeding. The development of these vegetative branches appears to be inimical to the production of fruit on the fruiting branches of the central axis of the plant. Excessive shedding in St. Vincent is due to disease (*Bacterium malvacearum*) and physiological reasons. Physiological shedding in St. Vincent is due mainly to a check in the assimilative activity of the leaves and not to root asphyxiation. Boll dropping would apparently be considerably reduced by planting (deferred) until late in August. [*Exp. Sta. Rec.*, 1925, **52**, 132 ; from *St. Vincent Agri. Dept. Rpts.*, 1921, pp. 4-15, 27-33 ; 1922, pp. 3-20, 27-33, fig. 1. SIR FRANCIS WATTS and others.]

COTTON FLEA IN S. TEXAS.

The capsid, *Psallus seriatus* Reut., is thought to be responsible for serious damage to cotton in S. Texas. During 1923 the loss from this cause was much greater than from the boll weevil, no crop whatever having been produced on hundreds of fields ;

and in 1924, though the injury was much less, it was still very considerable in Calhoun and neighbouring countries on the coast. The damage is thought to be due to the transmission of a virus, which results in the blasting of young squares, a reduction in fruiting branches and the excessive growth of the main stem. A similar foim of injury was reported in July 1924 in Georgia and S. Carolina. [*Exp. Sta. Rec.*, 1925, **52**, 454 ; from *Jour. Econ. Ent.*, 1924, **17**, 604. W. D. HUNTER.]

TEXAS ROOT ROT FUNGUS (OZONIUM OMNIVORUM).

A study of the life-history of *Ozonium omnivorum*, the fungus responsible for the root rot of cotton in Texas, is described. Numerous cultures were made on different media and kept under different conditions, but they always remained sterile. The author found what he believes to be the perfect stage of this *Ozonium* on a sprout of osage orange growing in the neighbourhood of a cotton field " dead spot " in which the plants had all been killed by this fungus. An examination of the wilted plant showed that the typical mycelial strands of yellowish hyphæ extended up the stem several inches from the soil and there began to change into a subiculum which surrounded the stem and formed a hymenium with the typical spines of a species of Hydnum, a description of which is given. [*Jour. Agri. Res.*, 1925, **30**, 474-477. C. L. SHEAR.]

REVERSING SPIRAL MEASUREMENTS OF COTTON HAIR.

Selections from a mass of statistical data describing the dimensions and form of the spiral arrangements which occur in the cell wall of cotton hairs are presented. The spirals may be dexter or sinister, and their reversals are apparently predetermined during growth in length. Genetic and ordinary environmental influences do not affect the statistical peculiarities of the reversals. The final adult length of the hair and the time taken in reaching that length, do affect the reversal distribution. Nearly all the seed hairs of *Gossypium* begin to grow on a sinistral spiral, *i.e.*, the opposite hand to an ordinary screw thread. The basal sinistral spiral increases in length, is broken up, and later additions may be made to its fragments. Similar extension, fragmentation, and subsequent addition take place with the later dextral spiral. The angle of the helix varies somewhat around two nodal values, namely, approximately 27° dexter and 27° sinister. The local variations of the angular value are quite unaffected by inversion of the " hand " of the angle from dexter to sinister. Dexter and sini ter wall struc!ures have been found in some hairs to have different structural properties in th ir resistance to collapse after the death of the cell. A tentative explanat:on of the cause of reversal is offered, but attention is drawn to its insufficiency and to the need for experimental evidence. [*Proc. Roy. Soc.*, 1926, **99B**, 130-147. W. L. BALLS and H. A. HANCOCK.]

Cotton Cultivation in Barbados.

There were 2,687 acres under cotton, which yielded a total of 1,606,781 lb. seed cotton, or, at an average ginnery outturn of 24·5 per cent., 393,340 lb. lint, *i.e.*, 146 lb. per acre, and 1,183,231 lb. of seed. Exports for the year October 1923 to September 30th, 1924, amount to 791 bales of 505·4 lb. weighing in all 409,767 lb. and valued at £37,561 or an average of 22*d*. a lb.

The pink bollworm is now to be found in all the cotton districts of the islan and preventive measures are enforced by law. The leaf blister mite and the cotto aphis did little damage during this season.

Yields of over 1,000 lb. seed cotton per acre were obtained in certain districts. Extensive meteorological data are given for the whole of the island. [*Rept. Dept. Agri., Barbados*, 1924-1925.]

Structure and Swelling of Cotton Hairs.

The author suggests that in comparing cottons, measurements of cross sectional area should replace measurements of staple length, as being capable of more accurate determination. He refers to some detailed but not widely known investigations of Corda, and gives a table showing some of Corda's measurements of diameters of uncollapsed and collapsed hairs and also of wall thickness. He describes Herzog's method of measuring cross-sectional area, but rejects the method as impracticable. The author describes a new method of arriving at the area of cross section from measurement of the weight of a known number of hairs of measured length. The weight is obtained on a Kuhlmann micro-balance to a degree of accuracy of 1 per cent. and the weight involved requires the counting and measuring of only some 30-100 hairs, which it is claimed takes not more than 10-30 minutes after practice. Details of the weighing operation and length measurement under the microscope are given, together with a table of results. Investigations into the convolution of the cotton hair in the dry and wet condition are described, and the results indicate that the number of half convolutions calculated in the manner described in the wet hair is only about half that of the dry hair. The latter part of the paper is devoted to the structure of the hair and to the phenomenon of swelling. A method of isolating the cuticle is described, and an illustrated account of the structure and characteristic markings of the cuticle is given. The spiral fibrillar structure of the cell wall is described in detail, with slides, and the relationship between convolution and spiral structure, and the significance of the grooves or folds observed in the hair, are discussed. The complicated phenomena of swelling may be largely explained from considerations of structure of the hair. Swelling or non-swelling is determined *inter alia* by the direction of diffusion of the reagent causing swelling, [*Z. angew. Bot.*, 1925, **7**, 57-73. O. Dischendorfer.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

We offer hearty felicitations to Dr. E. J. Butler, C.I.E., on his admission as a Fellow of the Royal Society. He is the first member of the Indian Agricultural Service to be so honoured.

His Majesty the King-Emperor's Birthday Honours List contains the following names which will be of interest to the Agricultural Department :—

C. I. E.—Mr. G. S. Bajpai, C.B.E., I.C.S., Offg. Deputy Secretary to the Government of India, Department of Education, Health and Lands.
Mr. G. Clarke, F.I.C., F.C.S., Director of Agriculture, United Provinces.

Khan Bahadur.—Khan Sahib Maulvi Fateh-ud-din, B.A., M.R.A.S., A.R.H.S., Personal Assistant to the Director of Agriculture, Punjab.

Rai Bahadur.—Rai Sahib Tundi Lal Powar, B.A., Extra Assistant Director of Agriculture, Central Provinces.

Khan Sahib.—Maulvi Abdur Rahman Khan, First Assistant to the Imperial Economic Botanist, Agricultural Research Institute, Pusa.

Mr. J. A. Madan, I.C.S., assumed charge of the duties of Joint Secretary to the Royal Commission on Agriculture on 1st July, 1926.

Mr. W. J. Jenkins, M.A., B.Sc., has been appointed to officiate as Secretary, Indian Central Cotton Committee, Bombay, *vice* Mr. B. C. Burt on leave.

Mr. A. M. Mustafa, B.A., Bar-at-Law, has been appointed Agronomist at the Agricultural Research Institute, Pusa.

Babu Kalipada Maitra, Special Water Hyacinth Officer, Bengal, has been allowed privilege leave for two months.

MR. R. BRANFORD, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar, has been granted leave on average pay for eight months. He made over charge of his duties to Messrs. W. S. Reid and Gulam Hussain on 28th March, 1926.

MR. F. D. ODELL, B.A., Deputy Director of Agriculture, West Central Circle, Burma, has been granted combined leave for eight months. U Maung Gale, Assistant Director, has been placed in charge of the Circle, in addition to his own duties.

The Fourteenth Meeting of the Indian Science Congress will be held in Lahore from 3rd to 8th January, 1927, under the presidentship of Sir J. C. Bose, F.R.S.

The Sectional Presidents will be :—

Agriculture.—Mr. F. J. Warth, Physiological Chemist, Imperial Institute of Animal Husbandry and Dairying, Bangalore.

Mathematics and Physics.—Dr. D. M. Bose, Professor of Physics, University College of Science, Calcutta.

Chemistry.—Dr. H. K. Sen, Professor of Applied Chemistry, University College of Science, Calcutta.

Zoology.—Major R. B. S. Sewell, Director, Zoological Survey of India, Calcutta.

Botany.—Dr. M. A. Sampathkumaran, Professor of Botany, Central College, Bangalore.

Geology.—Dr. L. Dudley-Stamp, Professor of Geology, University of Rangoon.

Medical and Veterinary Research.—Major R. N. Chopra, School of Tropical Medicine, Calcutta.

Anthropology.—Dr. J. H. Hutton, C.I.E., Deputy Commissioner, Assam.

Psychology.—Major Owen Berkeley-Hill, Ranchi.

The All-India Poultry Exhibition will be held at Calcutta from 9th to 11th December, 1926. On the second day, a Conference of all interested in the promotion of poultry farming in India will meet under the patronage of Dr. D. Clouston, C.I.E., and under the chairmanship of Dr. Harold H. Mann. A fee of Rs. 5 has been fixed for registration of members who are invited to send to Mrs. A. K. Fawkes, Lucknow, before 1st October, 1926, any papers which they propose to contribute to the Conference.

REVIEWS

The Storage of Eggs.—Special Report No. 26 of the Food Investigation Board of the Department of Scientific and Industrial Research. By T. Moran and J. Pique. Pp. viii+80+9 plates. (London: H. M. Stationery Office.) Price 1*s*. 3*d*.

The report is full of most valuable information to those desiring to place their surplus production of eggs in cold storage.

Results of careful experiments into the effect of temperature upon eggs reveal new and startling theories, among which we notice with great interest that fertile eggs maintain their fertility best and for the longest space of time in the region of 46·4° F. to 50·0° F. and that this maximum period is determined by the strain of the fowls. It is suggested that some degree of incubation starts at as low a point as 60·8° F. and therefore the storage qualities of eggs are lessened by any exposure to air temperatures above this point. One day's normal incubation or exposure of the egg to a temperature of 68° F. to 79·8° F. will reduce the storage life of an egg from 21 days to six days. On the other hand, the life of a fertile egg is also considerably reduced by exposure to temperatures below freezing point, so that the practical conclusion is that eggs should be stored at a temperature of 32° to 33° F. only, with the humidity of the air in the store constant at 80 per cent. combined with continuous circulation of the air in the store. Freezing of the egg must be avoided; on removing from the store de-frosting or gradual return to warmer temperatures is necessary to prevent the sweating and consequent spoiling of the stored egg.

Valuable advice as to packing eggs intended for storage is given, as well as interesting information regarding the testing of eggs for freshness and condition.

For small holders waterglass solution of 5 per cent. strength is recommended for the preservation of eggs, though it is pointed out that a cool place is required where, if possible, the temperature should be constant in the range of 33° F. to 45° F. for successful preservation of such eggs.

We regret that no information is given as to the superiority of infertile as against fertile eggs for cold storage; we would imagine the former to be infinitely better; it is merely stated that there is no objection to storing fertile eggs, provided they have not been subjected to high temperatures.

As Great Britain imports annually eggs to the value of nearly £14 million sterling, it is a point of great commercial value to her that none of her surplus production of eggs in the summer season be wasted; therefore this Report must be of infinite value

to the owners of cold storage plants at home. It is of value to us here in India also in that it shows that we have little hope ever of competing successfully in the egg trade with the West by means of the cold storage method, as eggs in this country are seldom, if ever, laid in a temperature less than 60° F., except in the hills under winter conditions. Therefore it is well-nigh impossible for us to collect eggs under the correct conditions previous to cold storage.

Our only solution is by means of machinery to convert eggs into a dessicated powder which will keep good for a long time, and it is this trade which we hope will be developed in India in the future. Our peasants could be taught to store their surplus eggs in waterglass or lime water in underground pits that would maintain an even temperature somewhere near the ideal which the report proves advisable. These stored eggs could be used in the above mentioned factories for dried eggs, or even sold in the cold season in the bazaar when eggs fetch high prices.

We would urge all poultry farmers to study this valuable work on eggs, as it is of absorbing interest. [A. K. F.]

The Cotton Growing Countries: PRESENT AND POTENTIAL PRODUCTION, TRADE AND CONSUMPTION. International Institute of Agriculture, Rome. (London: P. S. KING & Co.) Price 12*s*. 6*d*.

This is a revised and enlarged edition of the International Institute's monograph "The Cotton Growing Countries" which first appeared in 1922. The new monograph presents in a convenient form a general survey of cotton production in the world and includes a valuable statistical appendix. The progress of the crop in the principal producing countries is well discussed and much valuable information given about the progress of cotton growing in countries and areas where the crop is comparatively new. [B. C. B.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Wheat-breeding Investigations at the Plant-breeding Institute, Cambridge, by Sir R. H. Biffen and F. L. Engledow. Ministry of Agriculture Research Monograph No. 4. (London : H. M. Stationery Office.) Price 4*s*. net.
2. Catalogue of the Printed Books on Agriculture published between 1471 and 1840, with Notes on the Authors, by Mary S. Aslin. Pp. 331+22 plates. (Harpenden, Herts : Rothamsted Experimental Station.) Price 12*s*.
3. Soil and Civilization : A Modern Concept of the Soil and the Historical Development of Agriculture, by M. Whitney. Pp. x+278+5 plates. (London : Chapman & Hall, Ltd.) Price 15*s*. net.
4. Dairy Cattle : Selection, Feeding and Management, by W. W. Yapp and W. B. Nevens. Pp. xvii+378. (London : Chapman and Hall.) Price 11*s*. net.
5. The Nervous Mechanism of Plants, by Sir J. C. Bose. Pp. xix+224. (London : Longmans, Green & Co.) Price 16*s*. net.
6. Citrus Diseases and their Control, by Howard S. Fawcett ; with sections on Oriental Citrus Diseases, by H. Atherton Lee. Pp. xii+582 ; 205 figs. (New York : McGraw-Hill Book Co.) Price $ 3.

The following publication has been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoir.

1. Nutrients required for Growth Production with Indian Food-stuffs, by F. J. Warth, M.Sc., and Izaz Ahmd, B.Sc. Ag. (Chemical Series, Vol. VIII, No. 11.) Price As. 3 or 4*d*.

PLATE XXIX.

CLAUD MACKENZIE HUTCHINSON, C.I.E., B.A.,
Imperial Agricultural Bacteriologist, 1909—1926.

ORIGINAL ARTICLES

C. M. HUTCHINSON, Esq., C.I.E., B.A.,

Imperial Agricultural Bacteriologist, 1909-1926.

AN APPRECIATION.

On the retiring of Claud Mackenzie Hutchinson early this year, India and the Imperial Department of Agriculture lost its pioneer worker in soil bacteriology. The post of Imperial Agricultural Bacteriologist was one of the original posts as Head of a Section created at the foundation of Pusa, but the Section did not start work till the appointment of Hutchinson in December 1909. Hutchinson was educated at Glenalmond and St. John's College, Cambridge, where he graduated in 1891.

Pusa was fortunate in securing a man of the experience and capacity of Hutchinson to work in the virgin field of agricultural bacteriology, for he had had some years of experience of research work in India with the Indian Tea Association, to which he was appointed in April 1904 as Assistant Scientific Officer, and in May 1907 he succeeded Dr. Harold Mann as Chief Scientific Officer. Unfortunately his health failed to stand the climate of Assam, and compelled him to resign early in 1909. While with the Tea Association he engaged in fruitful investigations on red rust in tea, and on taints in packed tea, as well as the manurial and other experiments conducted at the Heeleakea Experiment Station.

His experience in equipping a laboratory and in the laying down of experimental plots and the appreciation of the yields from such plots was of exceptional value both to himself and to the department on his appointment to Pusa. Here he had to start afresh, equipping his laboratory and training assistants. The laboratory accommodation available in the main building was inadequate, and there was no provision made for experimental plots. He therefore had an outside laboratory and pot culture house built, and a small area laid down in experimental plots. Before he retired, the laboratory accommodation and equipment of the Section had improved out of all recognition, and assistants or students trained under his direction were to be found in most of the provinces.

One of the most striking features of his work at Pusa is the astonishing variety of problems in the solution of which he was engaged. In addition to his work on soil biology, dealing with the problems connected with the nitrogen supply in soils, the utilization of indigenous sources of phosphoric acid, green-manuring, the production by bacterial agency of substances toxic to plant life, he also published work on bacterial diseases of plants, diseases of silkworms, alcoholic fermentation,

bacterial activities in indigo manufacture, and on the manufacture of stable hypochlorite solutions for water sterilization and antiseptic purposes.

His interests were many-sided. He was an exceptionally gifted photographer, and during the years in which he had charge of the photographic work at Pusa the quality of that work was vastly improved. In his last year at Pusa he devoted much time and care to the preparation of a series of cinema films of agricultural operations, which in the plains of India during the hot weather and rains makes large demands on the patience, skill and ingenuity of the operator.

From its infancy, he was interested in motoring, and was one of the earliest motorists in North Bihar.

In his first few years at Pusa he took an active part in all the out-door games of the station, but later was compelled by indifferent health to desist from the more strenuous of them. He was responsible for the present golf course at Pusa, and his advice on the laying down and management of turf for greens and fairways was often sought and freely given.

The merit of his scientific work received official recognition in 1920, when he was created a C.I.E.

His departure is a distinct loss to the department and leaves a gap in the ranks of workers in the cause of agricultural science in India that will be hard to fill. [J. H. W.]

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, MR. J. T. EDWARDS (ON LEAVE); *Secretary for Publications*, MR. S. K. SEN).]

VIII. VACCINATION AGAINST BLACKQUARTER IN CATTLE AND SHEEP.

The experience of many workers abroad and of this Institute during the last four years indicates that a satisfactory, active or prolonged immunity can be set up against the above disease by preventive inoculation with a "germ-free," safe product commonly known as an "aggressin." The "aggressin" is prepared by cultivating the germs of blackquarter in suitable culture media or animal tissues, the extracts of which after filtration through a bacterial filter are "germ-free." The "germ-free" filtrate thus obtained contains certain properties elaborated by the germs that are known as "aggressins," which are held to be non-toxic in themselves but enable the germs when they gain entrance into the body to gain a foothold, or become "aggressive"; without the support of these so-called "aggressins" the germs would be innocuous. After inoculation with the germ-free fluid containing these "aggressins" the animal body develops in the course of a few days an active immunity against them, which enables the animal subsequently to withstand invasion with the germs of blackquarter. It will be understood that during the few days (5 to 7) that the body is developing this response it is still susceptible, and the "aggressins" may aid actually in developing the infection. For short, the "germ-free" fluid containing the "aggressins" is issued under the name "blackquarter aggressin."

For many years, blackquarter was understood to be caused by a specific germ, the bacillus of blackquarter. Modern researches have shown that cattle become affected with disease that cannot be diagnosed clinically otherwise than as blackquarter, caused by more than one germ. In addition to the germ originally known as the bacillus of blackquarter, now commonly more precisely known as *Bacillus chauvoei*, cases of blackquarter occur which are set up by the germs of what has been termed "malignant oedema" or "gas gangrene," and the most notable of these germs goes by the name *Vibrion septique*. In India, sporadic cases of blackquarter have been actually found to be caused by the germs of malignant oedema, and not by the true blackquarter bacillus, *B. chauvoei*. We have reason to believe, however, that veritable outbreaks of blackquarter are caused by the true blackquarter bacillus, while sporadic cases, especially those associated with traumatism, may be caused by the other organisms of the malignant oedema group.

Hence, the "blackquarter aggressin" issued from Muktesar for preventive inoculation has been prepared from what has been authentically determined to be

B. chauvoei as well as from about one hundred " strains " derived from material kindly forwarded to the laboratory by veterinary workers from various parts of India. The " aggressin " may therefore be termed a " polyvalent " one.

The dose of the " blackquarter aggressin " for cattle varies from 5 to 10 c. c., depending on the size of the animals, inoculated subcutaneously. For sheep, the dose is proportionately smaller, 1 to 2 c.c.

Animals should be inoculated preventively about one month before the onset of the season when outbreaks are commonly known to occur. It is a wise plan to repeat the inoculation in about 9 to 10 days, for the reason that a single inoculation is not highly effective as a means of intervention to ward off infection due to some of the " malignant oedema " organisms : a single inoculation, however, appears to be sufficient to protect against infection due to *B. chauvoci*. The artificial immunity set up is believed to remain sufficiently strong to prevent natural infection for at least a year, which covers the time in an animal's life when it is most susceptible to blackquarter, and hence calves or yearlings may obtain in this manner adequate protection to carry them through to the time when they develop sufficient natural immunity.

The " blackquarter aggressin " possesses the following marked advantages over the older, powder or pillule (Arloing's) form of vaccine :—(i) It is safe ; (ii) it is conveniently administered, by subcutaneous inoculation ; (iii) its mode of manufacture can be more readily regulated so as to obtain an efficacious product. The powder or pillule form of vaccine, on the other hand, has these disadvantages :—(i) It acts in virtue of containing minimal numbers of active, fully virulent spores of the blackquarter germs ; (ii) if excessive care is taken to make the vaccine " safe " it is likely to be inefficacious ; (iii) if steps are taken to ensure that it is undoubtedly efficacious, then it is likely that a dose may contain a dangerous amount of the living germ. These defects have been ascertained to be of frequent actual occurrence. Sufficient evidence is now deemed to have been obtained concerning the efficacy and safety of the new product, " blackquarter aggressin," when applied in ordinary field conditions in India, and hence in future it is intended to issue this product to comply with indents, except when indenting officers distinctly specify that they require the " pillule " vaccine. Adequate stocks of the " aggressin " are in course of preparation to meet all likely demands.

The Institute also manufactures an anti-blackquarter serum for issue. The serum is of value in cutting short the spread of blackquarter in the scene of actual outbreaks, especially those that are running a very virulent course. In such outbreaks the best method to adopt is to inoculate all the animals exposed to danger with a dose of anti-serum (dose for cattle=15 c.c.). The protection conferred by the serum, however, lasts only about 9 days, and hence in order to obtain a durable immunity the animals should be inoculated simultaneously with the " blackquarter aggressin."

RICE SEED-TESTING.

BY

S. K. MITRA, M.S., PH.D.,

Economic Botanist to the Government of Assam;

AND

PARESH MOHON GANGULY,

Botanical Assistant.

AN experiment to test the viability of paddy seeds of different varieties, ranging from one to three-year old, was commenced at the Karimganj farm in January 1923. Seed-testing is still being continued for further study. In order to carry out the work satisfactorily five seed-testing wooden boxes of the size of 25″ × 25″ × 4″ were made for the purpose. As rats are a common pest in the farm the boxes were fitted with wire gauze lids.

The boxes were filled with two-inch thick sawdust. A piece of blotting paper marked with 2″ × 2″ squares, having one-half inch interspace between them, was then placed over the sawdust which was always kept soaked by sprinkling water. A hundred grains of a variety were put in each square. A small piece of blotting paper was pinned over the grains in each square with a small label so as to keep the grains intact. They were then covered with a large sheet of moist blotting paper. This double covering was adopted for the reason that as the paddy seeds are hairy they adhere to the paper as soon as it is put on and are easily displaced each time the blotting cover is lifted. The seeds were thus kept soaked by sprinkling water at intervals for some days until they stopped germination. The number of germinated seeds was calculated for each variety and the percentage of viability determined.

Experiments on seed-testing were carried on under three heads as follows:— (1) Viability of rice seeds for three successive generations; (2) comparative germination of old and new rice seeds; (3) resting period and germinating capacity of rice seeds. In all cases sound seeds of each variety were used for the germinating test.

VIABIITY OF SEEDS FOR THREE SUCCESSIVE GENERATIONS.

A—*Sail*. One hundred and sixty-seven types of *sail* paddy were tested. The seeds of 1922 germinated almost cent per cent. Of the 1921 seeds only 38 varieties

germinated, while the rest showed no sign of germination, the percentage of germination varying from 1—56 per cent. Of these, only 8 varieties germinated 40—56 per cent. and 18 varieties below 10 per cent. The average percentage was calculated to be only 4. Many seeds gave out a very weak caulicle, showing their weak vitality, and were not strong enough to grow in the field. The seeds of 1920 showed negative results.

B—Aus. (i) Fifty-six types of broadcast *aus* were tested for germination. The 1922 seeds germinated satisfactorily. Of the 1921 seeds 45 types germinated; the percentage of germination varied from 5—99 per cent., the average being 57 per cent. Only 10 varieties germinated below 50 per cent. and 19 varieties 90 per cent. and upwards. The seeds of 1920 did not germinate at all.

(ii) Eighty-one types of transplanted *aus* were taken for germination. The 1922 seeds germinated well. Of the 1921 seeds 61 types germinated. The percentage of germination varied from 2—99 per cent. (9 varieties below 10 per cent., 8 varieties 90 per cent. and upwards), having an average of 35 per cent. The seeds of 1920 proved abortive.

C—Asra. Thirty types were tested. Only the 1922 seeds germinated, while both 1921 and 1920 seeds did not germinate at all.

The viability of paddy seeds differs a great deal in different classes and also among the individual varieties to a certain extent.

The following table will show the percentage of germination of paddy seeds for three successive generations :—

TABLE I.

Percentage of germination of rice seeds for three successive generations.

Class of paddy	Years	No of varieties tested	No. of varieties germinated	Range of percentage of germination	Average percentage	REMARKS
Sail	1920	167	nil	nil	nil	The seeds were tested in April 1922.
	1921	167	38	1—56	4	
	1922	167	167	100	100	
Broadcast Aus	1920	56	nil	nil	nil	
	1921	56	45	5—99	57	
	1922	56	56	100	100	
Transplanted Aus	1920	81	nil	nil	nil	
	1921	81	61	2—99	35	
	1922	81	81	100	100	
Asra	1920	30	nil	nil	nil	
	1921	30	1	2	0·07 or nil	
	1922	30	30	100	100	

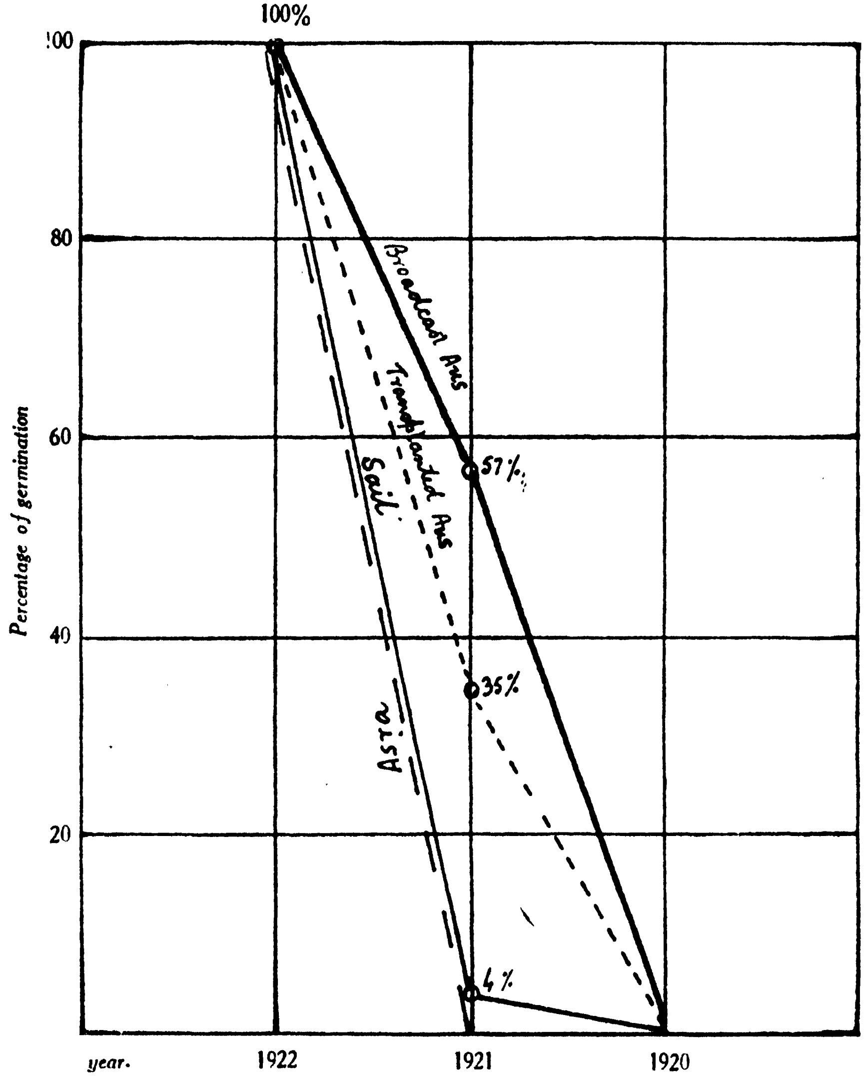


Fig. 1. Curves showing the percentage of germination of rice seeds for three successive generations from 1920-1922.

From Table I and the curves in Fig. I, we see that broadcast and transplanted *aus* have better germinating capacity than *sail* and *asra*, while the percentage of germination is the lowest in *asra* and that three-year old seeds cease to be productive in any case.

Comparative germination of old and new seeds.

The rate of germination of rice seeds differs in different classes and also among the individuals of the same variety. Furthermore, old seeds germinate rather

more slowly than new seeds. Table II shows a comparison of the rapidity of germination of different classes of rice seeds, both old and new. The modes in the two sets of curves in Fig. 2 indicate the highest number of seeds germinated in old and new seeds on the sixth and the third day respectively.

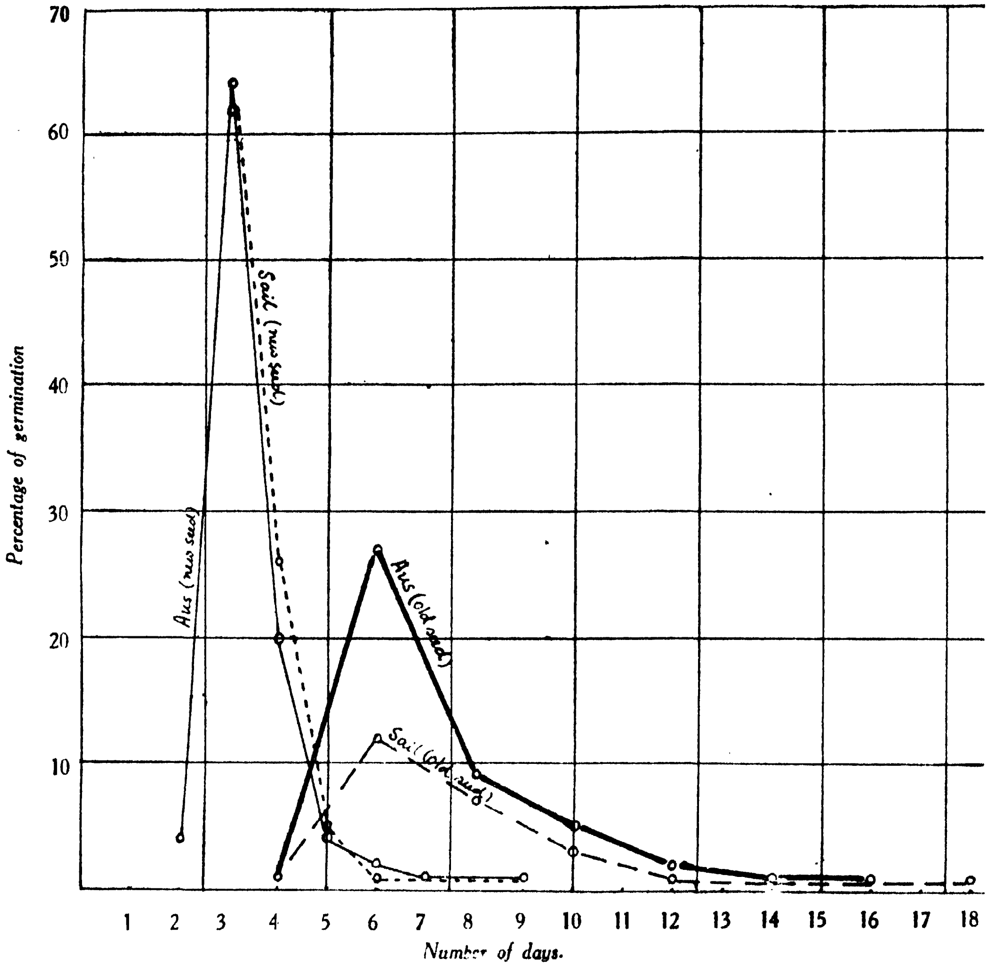


Fig. 2. Showing the rate of comparative germination of old and new seeds.

From Table II and the curves in Fig. 2, it is evident that the percentage of germination is more rapid in the case of *aus* than *sail*. Moreover, old seeds cover a longer period for germination and the percentage of germination is very low. It may be mentioned here that only one-year old seeds were taken both of *aus* and *sail* for comparison with fresh seeds.

TABLE II.

Comparative germination of old and new seeds.

Class of paddy	Number of days																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Aus (fresh seed) .	..	4	64	20	4	2	1	..	1	..	..	..	..	..	..	..	..	..	96
Aus (one-year old seed).	..	..	..	1	..	27	..	9	..	5	..	2	..	1	..	1	..	..	46
Sail (fresh seed) .	..	..	62	26	5	1	1	..	1	..	..	..	..	..	..	..	..	..	96
Sail (one-year old seed).	..	..	..	1	..	12	..	7	..	3	..	1	..	1	..	1	..	1	27

Almost all new seeds germinated within five days from the date the test was started, whereas old seeds continued to germinate up to the eighteenth day when germination stopped. It may also be mentioned here that in old seeds which germinated late, in some cases rot ensued in the caulicle after germination.

RESTING PERIOD AND GERMINATING CAPACITY OF RICE SEEDS.

There is always a certain resting period for all kinds of seeds more or less. To ascertain this a number of varieties, both *sail* and *aus*, were tested. Table III and the curves in Fig. 3 show clearly how the percentage of germination increases as the seeds grow older up to a certain period.

TABLE III.

Resting period and germinating capacity of rice seeds.

Class of paddy	Month and year	No. of varieties tested	No. of varieties germinated	Range of percentage of germination	Average percentage of germination	REMARKS
Sail . .	January 1923 .	35	21	4—88	12	The types were harvested in December 1922. In January one early type germinated up to 88 per cent. while others are below 35 per cent.
	February . .	48	43	2—98	27	
	March . .	45	45	14—100	86	
	April . .	13	13	84—100	96	
	July . . .	13	13	86—100	96	
	August . .	13	13	72—100	90	
	November . .	6	2	2—52	9	

Resting period and germinating capacity of rice seeds.

Class of paddy	Month and year	No. of varieties tested	No. of varieties germinated	Range of percentage of germination	Average. percentage of germination	REMARKS
Sail	January 1924	40	20	4—72	14	
	February	20	19	2—84	35	
	March	34	26	2—86	24	
	April	34	29	2—96	27	
	May	34	19	2—52	13	
	June	34	8	2—34	3	
	July	34	3	2—4	0·22 or nil	
Broadcast Aus.	August 1922	68	67	6—100	50	The types were harvested in July 1922.
	September	61	61	85—100	96	
	April 1923	50	50	89—100	96	
	August	50	50	86—100	96	
	December	40	35	12—85	50	
	March 1924	56	45	5—99	57	
	November	56	nil	nil	nil	
Transplanted Aus.	September 1922	12	12	4—100	56	The types were harvested in August 1922.
	October	12	12	92—100	96	
	April 1923	50	50	93—100	96	
	August	50	50	89—100	96	
	December	30	21	6—72	28	
	March 1924	81	61	2—99	35	
	November	81	nil	nil	nil	

From Table III and the curves in Fig. 3 it is evident that the fresh seeds of *sail* paddy do not germinate satisfactorily before March or April. The *aus* varieties, seem to have not much resting period, specially the *dumai* types, the seeds of which germinate even in the ear if they somehow come in contact with water. Other broad-

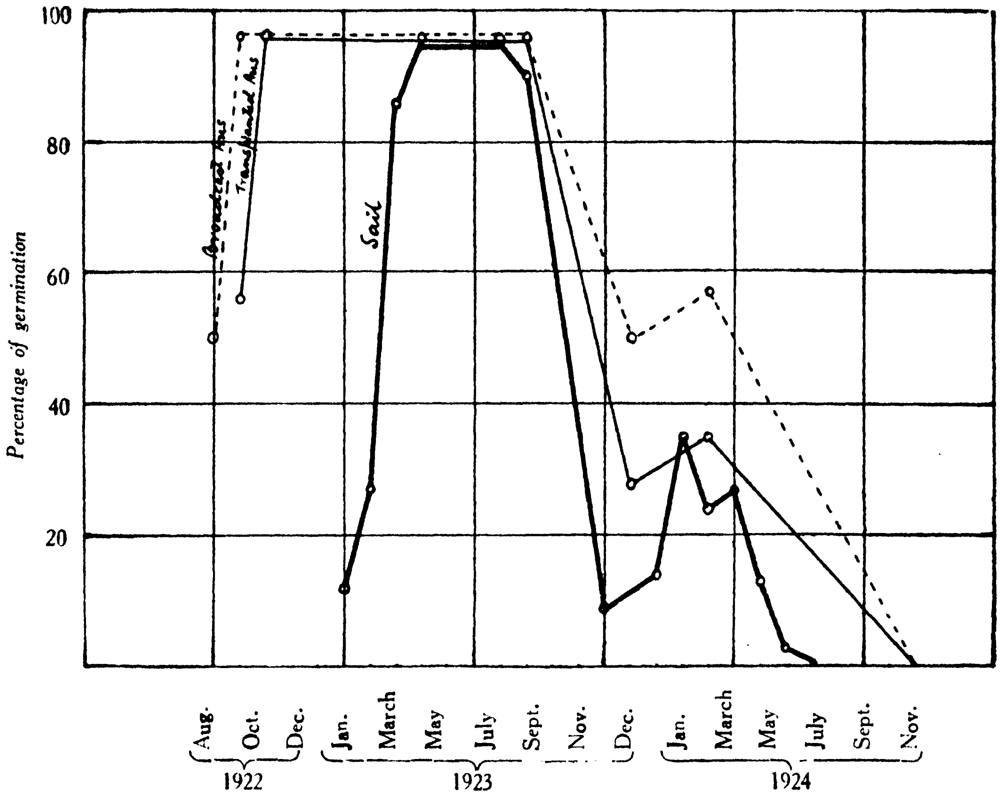


Fig. 3. Curves showing the resting period and germinating capacity of paddy seeds for three successive generations from 1922 to 1924.

cast *aus* varieties and also the transplanted *aus* varieties are found to have germinated in the same way. Complete germination both in broadcast and transplanted *aus* takes place in less than two months from harvesting. The seeds were taken for test after they were harvested and dried well. Though *sail* paddy is a cold weather crop, its prolonged dormancy may be supposed to be due to the intervention of the winter season.

Simultaneously, in order to find out the exact time when rice seeds cease to germinate, they were examined every month until the percentage of germination came to nil.

In Table III and the curves in Fig. 3 it is clearly shown that the germination of rice seeds begins with a low percentage and that it increases gradually until the maximum percentage is reached. The seeds keep up the maximum germinating strength for a certain length of time after which it begins to decrease until it comes to nil. In the case of *sail* paddy the germination begins with 12 per cent. in January 1923. It then increases until the maximum of 96 per cent. is reached in April 1923, which does not change up to July after which it begins to decrease slightly and in November

it has a sudden fall to 9 per cent. Although the percentage increases somewhat from February 1924 to April 1924, it finally comes to nil in July 1924. The condition is almost similar in both broadcast and transplanted *aus*, but in both cases the resting period is shorter and the period of germination capacity is longer than in *sail*. In fact the satisfactory germination capacity in *aus* remains intact for about 12 months from September 1922 to August 1923 after which it begins to deteriorate slowly until it comes to nil in November 1924.

It is also noticed in the table and curves that in most cases the percentage of germination which was low from November to January improved to some extent in the comparatively warmer months of February, March and April after which it again fell down. From the above fact it appears that the cold weather hinders the germination of rice seeds.

SUMMARY.

(1) Broadcast and transplanted *aus* paddies keep up their germination capacity, to a great extent, even in the second year. *Sail* paddy germinates very indifferently in the second year, while *asra* does not germinate after one year. Sail paddy germinates well up to August and September of the first year after which the seeds begin to lose their vitality until they become completely unproductive by June of the second year.

(2) New seeds germinate quicker than old seeds, and the germination is mostly complete within five days, whereas old seeds continue to germinate for a longer period.

(3) Fresh seeds of *sail* paddy do not germinate satisfactorily before March or April, *i.e.*, their resting period is from 3 to 4 months. The *aus* varieties have not much resting period, specially the *dumai* and *murali*. Complete germination of *aus* paddy takes place in less than two months.

A MOSAIC-LIKE DISEASE OF SUGARCANE IN THE CENTRAL PROVINCES IN 1926.

BY

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The mosaic disease of sugarcane in India was first discovered in 1921 at Pusa.[1] The canes affected were D. 99 and Sathi 131. Since then this disease was not reported from Pusa or any other part of India, till recently when the Imperial Mycologist informed the writer that it had been again observed at Pusa and also in the United Provinces. This led the writer to examine the sugarcane-growing farms in the Central Provinces to see if this disease was also present here.

On the Government farms in the Central Provinces, sugarcane is cultivated at Tharsa, Waraseoni, Sindewahi, Adhartal, Chhindwara, Drug, Chandkhuri and Bilaspur. Many varieties of cane, local and imported, were grown on these farms; some of them were grown extensively whereas others were for trial on a small scale. Four of these canes, *viz.*, Java 213, Khari, Co. 203, and Red Mauritius, were found to be affected by a mosaic-like disease, but this disease was observed only on those farms where Java 213 was grown. For example, on the farms in the Chhattisgarh Division, and at Sindewahi and Chhindwara, this variety had not been introduced and none of the canes was affected by this disease, not even Khari though it had been cultivated for several years, both as ratoon and from sets, on all these farms. Even in the cultivators' fields at Waraseoni and other places this variety was free from this disease. So far it was found to be infected only at the Adhartal farm where it was grown in several scattered blocks, but in all these blocks it was not diseased; this year, only those were observed to be infected which were in close proximity to Java 213 which was also cultivated in several scattered blocks. Khari seemed to be recently infected, because ratoon Khari between two blocks of Java 213 did not show much of the disease on mature canes, but new shoots and tillers from old clumps had badly mottled leaves; again in another block of Khari, raised from sets, adjoining a Java 213 block, new shoots from old clumps had typical mottling of the leaves, whereas the mature cane was hardly affected. In addition to Khari at Adhartal, Co. 203 and Red Mauritius, which had been growing near Java 213, were also found to be diseased. These canes like Khari seemed to be recently infected.

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[1] Dastur, J. F. The Mosaic Disease of Sugarcane in India. *Agri. Jour. India*, XVIII, pp. 505—509, 1923.

Java 213 was also grown at Tharsa and Waraseoni, and it was as uniformly affected on these farms as at Adhartal. All the plants showed the typical discoloured markings on the leaves, but except for these markings the crop was perfectly normal. This variety was first received from Dr. Barber from Coimbatore at the Tharsa Farm in April 1918. From Tharsa it was, in the last two or three years, distributed to the Adhartal and Waraseoni farms. It was grown both from sets and as ratoons. Some of the ratoons being at least three years old, still this cane showed no secondary symptoms of the disease, such as reduction in tonnage since its first introduction at Tharsa, splitting of the cane, shortening of the internodes, etc. It therefore appears that this disease has not the same deleterious effect on this variety as it has on susceptible canes in other parts of the world. Since the other canes, *viz.*, Khari, Co. 203 and Red Mauritius, seemed to be only recently infected, it is too early to say what the cumulative effect of this disease would be on these varieties.

Some of the varieties of cane which were growing in the immediate vicinity of Java 213, in addition to these three susceptible varieties, were Co. 226, Co. 219. Pounda, Co. 237, Co. 208, Sannabille, Co. 210, Co. 224, Co. 204 and Ashy Mauritius. Since these varieties were free from infection it may be that they are immune to this disease.

The reason why Khari at Tharsa and Waraseoni had not become infected, even though badly diseased Java 213 was extensively cultivated, might be due to the accident of this variety not having been grown in the immediate neighbourhood of Java 213.

Judging from the observations recorded it appears certain that Java 213 was the original source of infection to other canes. Since the first introduction of this cane in 1918 at Tharsa, from where it had been distributed to Adhartal and Waraseoni, it had not been reintroduced in these provinces, it is very probable that the original sets that were first received at Tharsa must have been from infected canes. There is also the probability that this variety might have caught the infection from another diseased variety which might have been subsequently introduced, and its further cultivation later dropped.

Though the symptoms of the disease are very typical still it is not unlikely that this disease may be overlooked, because markings which very closely stimulate those caused by the mosaic-like diseases are very often caused by insects and other agencies. Peculiar markings on canes were observed especially on Khari, Co. 219, Co. 210 and Dhaur which at first sight seemed very similar to those caused by mosaic and other similar diseases. However, they were not considered to be due to this class of disease because they were confined only to the opened leaves. The completely unopened leaves were uniform in colour and showed no markings whatsoever, the partially opened new leaves had the markings only on the upper exposed parts of the lamina, whereas the basal folded parts were perfectly free from the markings. Again the new shoots from sets recently planted and from ratoons after the mature canes had been cut were uniformly green in colour. The markings were not longi-

tudinal or in streaks. They were more or less round or oval, individual spots being very minute and the resemblance to mosaic markings being evident only in those canes where they were not scattered but were very closely associated together. Some of the Farm Superintendents were of opinion that these markings generally appeared year after year after the end of the rains. These markings were the result of insect bites.

At Drug, Khari showed a peculiar mottling on the leaves which very much resembled the mosaic-like markings on Java 213 and Khari and other canes, but the markings which consisted of stripes of different shades of green were confined only to the first two or three fully opened young leaves. The older mature leaves were uniformly normally green and the unopened leaves showed no markings whatsoever. The new shoots from sets planted this season and also shoots from clumps allowed to ratoon this year were normal in every way.

In a diseased cane the mottling is not confined only to a few leaves or to any particular part of the leaves; but is found on all the leaves, even on the partially opened and the completely folded immature leaves, and it involves the entire leaf blade.

The symptoms of the disease on Java 213, Khari, Co. 203 and Red Mauritius are all similar. They very much resemble those described by Storey from South Africa. As a result of the disease the normal uniformly green colour of the leaves is broken by stripes of light green or pale yellow in colour which run parallel to the veins, but which are generally not confluent; in these stripes from which the normal green colour has been washed out, as it were, are occasionally visible short thin dark green coloured lines, varying in length; at times yellow or light green thin lines are found embedded in the normal green colour of the leaves. In some cases the infected leaves are crinkled and generally stand erect and stiff, especially the young leaves from tillers. The important point of difference between this disease in the Central Provinces and the well known mosaic disease of cane in Java, Cuba, Porto Rico and other places, is that in the former case the patterns are in stripes of normal green colour and of yellowish or light green colour which run parallel to the veins and which do not run into each other. The discoloured portions do not form irregularly outlined islands or patches. Whereas in the mosaic disease the patterns do not necessarily run parallel to the veins and are not in stripes; the discoloured areas generally run across the veins and thus irregularly outlined designs are formed.

It is therefore considered that this disease in the Central Provinces is not exactly the mosaic disease described by Brandes[1] but is the streak disease described by Storey[2] from South Africa.

[1] Brandes, E. W. The Mosaic Disease of Sugarcane and other Grasses. *U. S. A. Dept. Agri. Bull.* 829, 1919.

[2] Storey H. H. Streak Disease of Sugarcane. *Dept. Agri. Union of South Africa Sc. Bull.* 39, 1925.

As yet no definite organism has been proved to be the cause of mosaic and streak diseases on cane and other hosts. Nelson[1] has found definite protozoan organisms in plants attacked by mosaic and related diseases. Kunkel[2] has seen intercellular bodies similar to Negri bodies in maize affected with mosaic. Matz[3] has found granular plasma-like bodies in diseased cells of yellow striped canes. But so far the presence of these foreign bodies in diseased cells has not been proved to be the cause of the disease.

Cytological study of the infected canes in the Central Provinces has shown the presence of foreign bodies in the tissues of infected canes, many of which are very similar to those described by Nelson. These protozoan-like bodies are found in all parts of the plants including the xylem vessels. As a rule, they are spindle-shaped with short or long flagella, one at each end, but the shape is not constant. The organism may adapt itself to the shape of the cell. In scleranchymatous cells with very thin lumen it is reduced almost to a long line. In small paranchymatous cells it is amœboid in shape with one or more pseudopodia. These foreign bodies seem to divide by longitudinal fissures. These bodies so far have not been found in healthy canes.

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[1] Nelson R. The Occurrence of Protozoa in Plants affected with Mosaic and Related Diseases *Agri. Expt. Sta. Michigan, Agri. Coll. Tech. Bull.* 58, 1922.

[2] Kunkel, L. O. A Possible Causative Agent for the Mosaic Disease of Corn. *Bull. Expt. Sta. Hawaiian Sugar Planters' Assoc., Bot. Ser.,* III, No. 1, pp. 1—14, 1922.

[3] Matz. J. Infection and nature of the Yellow Stripe Disease of Sugarcane (Mosaic, Mottling, etc.) *Jour. Dept. Agri. Porto Rico,* III, pp. 65—82, 1919.

LENGTH OF FIBRE AND GINNING PERCENTAGE IN INDIAN COTTONS.

BY

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In all efforts at improvement of agricultural crops, it is very essential to keep always in view the object for which the work is undertaken. Moreover, it is also equally desirable to divide the work in two stages. In the first stage, we try to investigate and find out the laws which control the inheritance of the different characters composing the plant. This is best done, in plants propagated by seed, by disturbing the normal relations of the various plant characters with one another in a pure culture by hybridization methods. This bringing together of a set of opposite characteristics admirably serves as a means to expose the laws under which the plant tries to regain its equilibrium which, theoretically considering, is perhaps never reached. But the process discloses to the observer the innate relations which exist between various characters, and these relations are either lost or maintained differently under abnormal conditions created in the hybrid by crossing. If the breeder is vigilant and keeps his object definitely in view, this preliminary study, of the inheritance of the individual characters and their mutual relation in subsequent generations, furnishes him with an insight which is very important for guiding him in selecting the material with which to work up his ideal. In the second stage, when he has to combine and fix up the different characters in directions useful to his purpose, the experience gained in the previous stage becomes an absolute necessity. Without passing through the former course, the breeder can hardly be successful in the latter. Here he has to build up his plant by carefully eliminating certain characters and by bringing together only those features which ultimately have to stand for and result in producing a commodity improved both quantitatively and qualitatively.

A study of the cotton plant, in both the abovementioned stages, shows that the economic features of a good cotton plant are manifold.. In general terms, the first requirement decidedly is that a plant should be able to grow under the climatic conditions in which it is sought to be introduced and cultivated later on. The next point to consider is that it should yield sufficient to make its cultivation profitable. Lastly, the quality of the produce should be such as to attract notice and to get better price in the market. It must also be pointed out that from the sowing

to the harvesting time the cotton crop, like all others, is subjected to different vagaries of the season, such as rainfall, sunshine, cloudiness, exposure to eastern and western winds. Artificial operations from time to time try to keep up the balance between the extreme conditions to which the crop is exposed during the growing period. The produce which the grower ultimately collects is thus a resultant product of all the conditions that have prevailed in the season. Seasonal conditions are never identical and their component factors fluctuate from year to year. The general average of their maximum and minimum limits characterizes a particular season. The produce is thus greatly influenced by the factors determining the seasonal changes. The success of the plant-breeder depends in producing and fixing such combinations of characters in his improved strain as are able, as far as practicable, to fit into the weather and soil conditions of the particular tract for which he is working. The seasonal variations affect the produce both in quantity and quality. Before one can go into the question of ascertaining the degree of such influences and also to measure the results they produce on the crop, it is first essential to study the variations that occur within the plant. As already stated, such study can extend to a number of characters of which the plant is composed. The inheritance of the combination of two or more such characters can next be undertaken. In the present study some phases of the two characters of length of fibre and the proportion of lint to seed, are considered.

In the United Provinces, cotton generally grown is of the type known as Bengals. It is characterized by having very short fibre. Some forms of Bengals such as *G. roseum* are high yielders, and the proportion of lint to seed is also greater than in other cottons, frequently touching 39 and 40 per cent.

In the experimental work on cotton research at Cawnpore it was required to produce a plant with improved staple but with as high a ginning percentage as possible. In the course of this work difficulties were experienced in combining these two characters as they appeared antagonistic. This has also been recognized by other workers. The President of the Agricultural Section of the Indian Science Congress held at Bangalore in 1924 said in his address :—" Within any agricultural variety there is undoubtedly a general tendency for long lint to be accompanied by a low proportion of lint and for short lint to be accompanied by a high ginning percentage. It is fairly clear that no complete linkage exists but there are probably limitations on the extent to which the two can be combined. Fuller knowledge on this question is clearly of great importance." Howard[1] confirms the same view when he says :—" It is well known that *as a rule* long staple cottons have a low ginning percentage, while short staple and high ginning percentage are frequently combined. It seems too much to hope therefore that a cotton will ever be found which combines the longest fibre and the highest ginning percentage." He, however, further adds :—" Kottur claims that he has combined length of fibre

[1] Howard, A. *Crop Production in India.*

and high ginning percentage in a cross between pure lines of *Gossypium herbaceum* and *Gossypium neglectum*."

Considering as a whole, the statements quoted above generally indicate a relation between long lint and low ginning percentage and short lint and high ginning percentage, and also appear to imply the probable existence of an intermediate stage, subject to certain limitations, where partial success may perhaps result from attempts at producing a high ginning and long linted cotton by hybridization methods. To determine as far as possible the range of those limitations and to ascertain the degree to which these two characters affect one another, by both pure line selection and hybridization methods, is the object of the present note.

The length of lint and ginning percentage, in the first place, are two such characters as are not truly comparable, because they are not exactly of the same description. Ginning percentage is a figure which is fairly complex as it is the resultant of more than one factor, *viz.*, the weight of the lint and the weight of seed, which may again vary, the former with the length and diameter of the individual fibres and the latter on account of its volume and specific gravity. The distribution of fibres on the surface of the seed may be sparse or dense and there may also be various intermediate stages. Therefore the length and diameter of the fibres being constant, their number in any given area, say per square millimeter, would considerably affect the weight of the lint. Leake[1] has shown that this "density" is the most potent and influential factor in determining the ginning percentage in Indian cottons. Length of the cotton fibre, on the other hand, is a comparatively simple character and varies considerably with the different botanical varieties of the cotton plant. It may be possible to find out the relation of this simple character of length with any one or more of the three component factors of ginning percentage, seed weight, lint weight, and density by going deep into the problem; but in the present study the comparison of length and ginning percentage has only been attempted on material collected from two sources :—

(*a*) Examination of many thousand samples collected from the fields of the cultivators.

(*b*) Examination of the progeny of crosses made between short staple plants with a high ginning percentage and long staple plants with a low ginning percentage.

On the recommendations of the Indian Cotton Committee, the United Provinces Department of Agriculture carried out a survey of the types of indigenous cottons growing in the different districts of the province. Three districts were only surveyed in this way. Almost all the villages in a district which grew cotton to an appreciable extent were visited and the lints were examined in the fields, and cotton from plants possessing a staple longer than the average was collected. All such collections were again examined in the laboratory and the best and the

[1] Leake, H. M. *Journal of Genetics*, Vol. IV, No. 1, June 1914.

longest sample only were kept for growing, and for further ascertaining their other economic and agricultural characters. In the course of handling and examining several thousand samples each year, for about three years while the cotton survey lasted, it was found that long staple cottons were invariably low in their ginning values. Short, dense, and coarse samples almost always stood comparatively higher in ginning percentage. As the object of the survey was to find out and fix a plant with long lint and high ginning percentage, and see if it could suit the short growing period of the cotton-growing tracts of the province, it appeared difficult or rather impossible to achieve the desired end.

About 500 selected samples collected from the various villages of the Saharanpur District were sown in 1921 and a crop of about 20,000 plants was raised. The examination of this collection in detail appeared to confirm the opinion that the long stapled plants were low and the short stapled high in the proportion of lint to seed. About 10 per cent. of these were selected and selfed on promising vegetative features, and the ginning percentage of the series is shown below :—

Ginning percentage	No. of cases
23—24	3
25—26	5
27—28	20
29—30	30
31—32	44
33—44	55
35—36	47
37—38	27
39—40	14
TOTAL	245

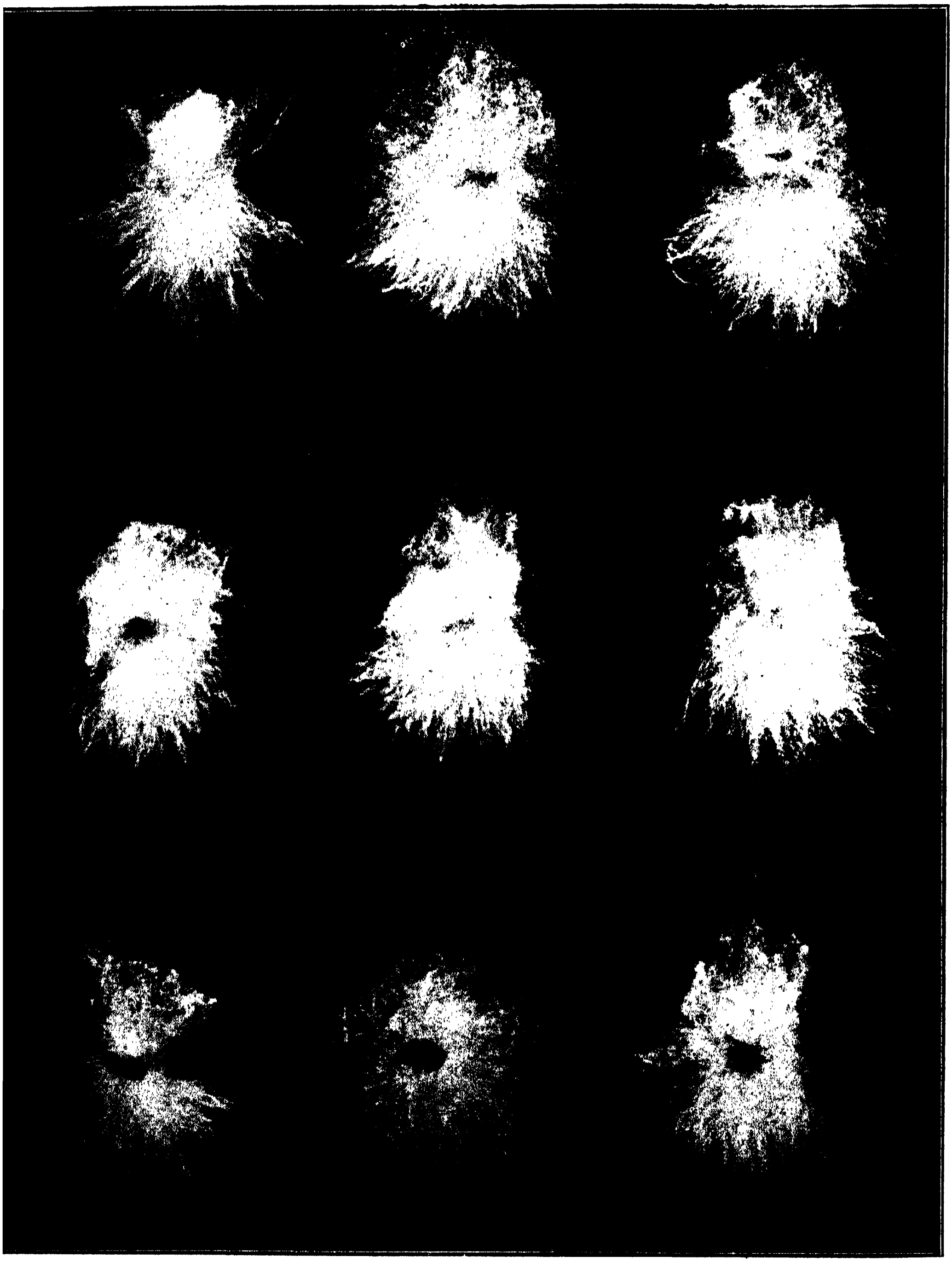
The lints of the high ginning individuals found in the last two classes of 37—38 and 39—40 were all within 18 to 22 mm. in length and none was above 22 mm.

If arranged in order of length of staple the following position appears :—

Length in mm.	No. of cases
18	3
20	106
22	90
24	43
26	3
TOTAL	245

Of the 43 plants giving 24 mm. length, only 8 touched the 35—36 range, otherwise all were 33—34 and below. Three plants with 25 mm. were also within the same range 35—36. The following table will more clearly illustrate the point discussed above.

PLATE XXX.



SHOWING DIFFERENCE IN THE LENGTH OF FIBRE OF DIFFERENT BOLLS ON THE SAME PLANT.

TABLE I.

Showing the dispersions of length and ginning percentage in a pure selected series.

Length	Ginning percentage									
	23—24	25—26	27—28	29—30	31—32	33—34	35—36	37—38	39	TOTAL
18	..	..	..	..	..	..	1	..	2	3
19—20	1	2	5	11	18	27	21	15	6	106
21—22	1	2	7	10	16	22	15	11	6	90
23—24	1	1	8	7	10	6	10	..	..	43
25—26	..	..	..	2	..	..	..	1	..	3
TOTAL .	3	5	20	30	44	55	47	27	14	245

In the whole series many plants with 34—35 ginning percentage were found which were excellent yielders and possessed nice long and soft fibres. But these could not be utilized for any purpose as the standard of requirement has been raised very high in the Agra Division, the main cotton tract of the province, by *Gossypiu roseum* which gins 39—40 per cent., and in the absence of an organized demand to pay for quality, the cultivators and purchasers of seed cotton look to the ginning percentage as the desirable feature. Fixing the ginning percentage of *G. roseum* as an irreducible minimum, attempt had to be made to improve the quality of the staple in length and fineness. But when the length increased the sample was found to drop in ginning percentage, and the result of the selection methods showed that the two characters had some mutual repulsive tendencies, and in the presence of the one the other character tended to get reduced. The 10 or 11 plants with 23 and 22 mm. lengths in the 35—36 and 37—38 per cent. lots when selfed were found to split up in both the length and ginning percentage characters, and their appearance under these headings should therefore be taken as transitory.

In the hybridization series, on the other hand, the same phenomenon was perceptibly visible, but the results were not so conclusive and disappointing as in the cotton survey series. Work on the hybridization of Indian cottons was started by Leake 20 years ago and the bearing of the investigations conducted by him, in respect of the point under consideration here, appears to be a little removed from the view held by other workers. In K. 22 (a purified form from a cross between *Gossypium arboreum* and *Gossypium roseum*) he succeeded in combining to a remarkable degree the high ginning percentage of *roseum* with a quality of fibre immensely superior to that borne by that strain. Had weak germination and late maturation

not stood in the way, K. 22 would have solved the cotton problem of the United Provinces. A series of K. 22 raised in 1923 from a pure culture is reproduced here with its length and ginning figures.

Ginning percentage	No. of cases
33—34	13
35—36	27
37—38	52
39—40	56
41—42	11
43—44	2
Total	161

In the order of the length of lint the series stands as under :—

Length in mm.	No. of cases
19—20	31
21—22	98
23—24	30
25—26	2
Total	161

By tabulating as before, this series shows the following order :-

TABLE II.

Showing dispersions in a series of a purified cross raised in its F_{18} generation.

Length in mm.	Ginning percentage						
	33—34	35—36	37—38	39—40	41—42	43—44	Total
19—20	2	4	8	13	3	1	31
21—22	7	15	34	33	8	1	98
23—24	4	7	10	9	..	..	30
25—26	..	1	..	1	..	..	2
Total	13	27	52	56	11	2	161

Though the range in length does not much differ from that found in the cotton survey series, yet the clustering of higher ginning values around the 39—40 level

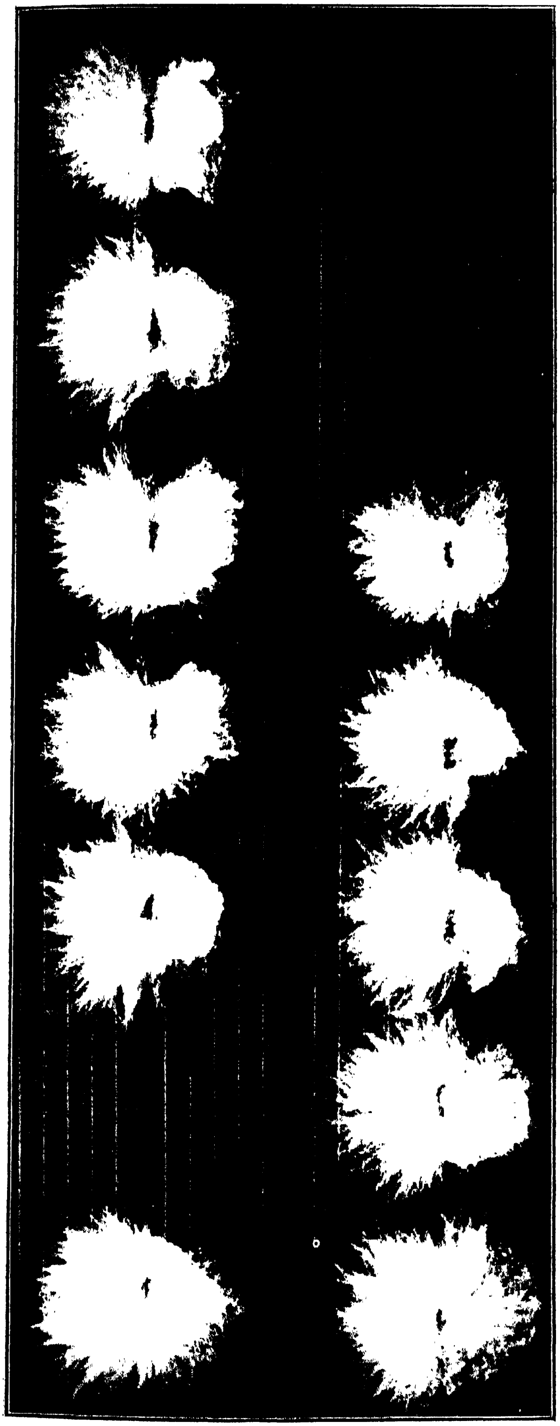
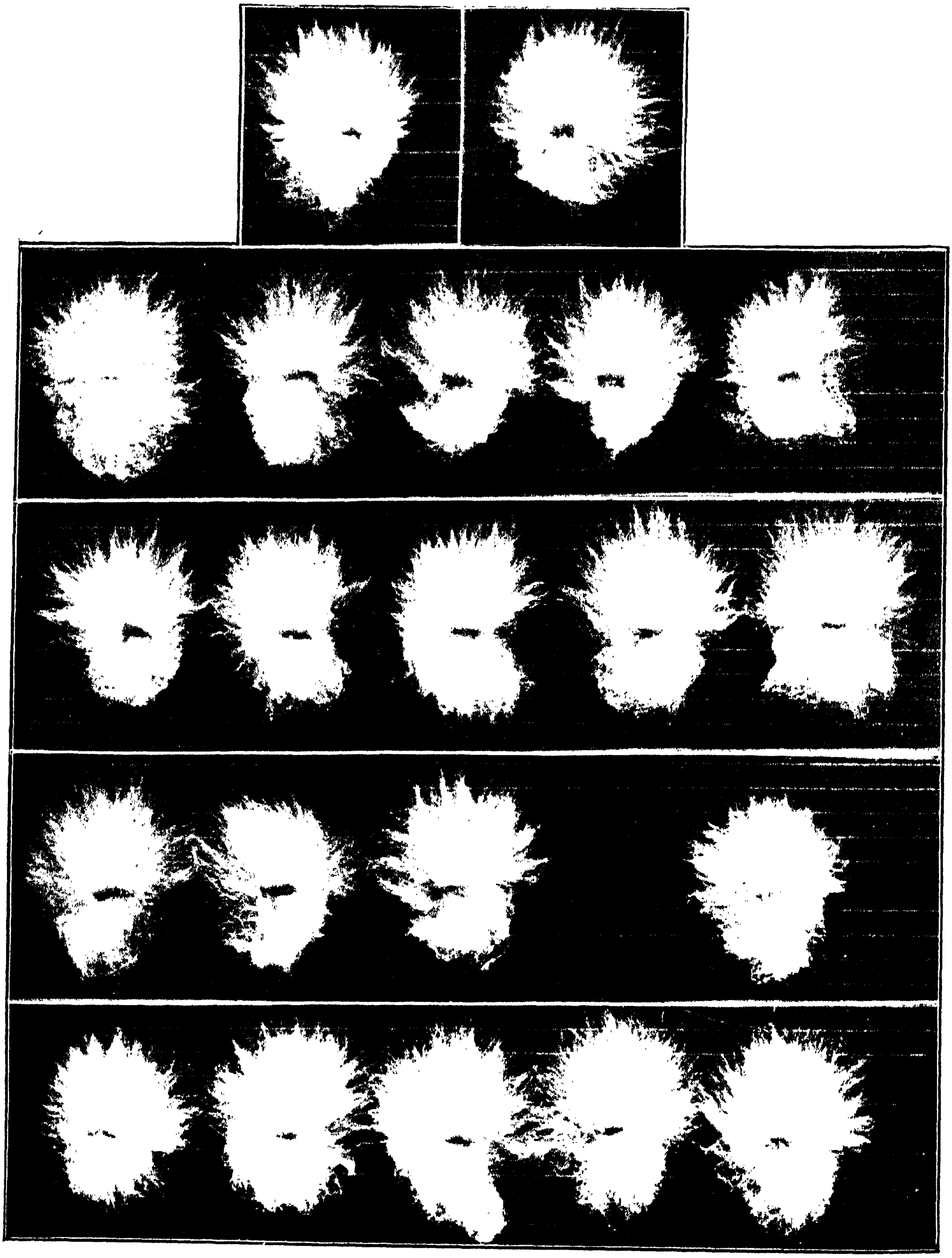


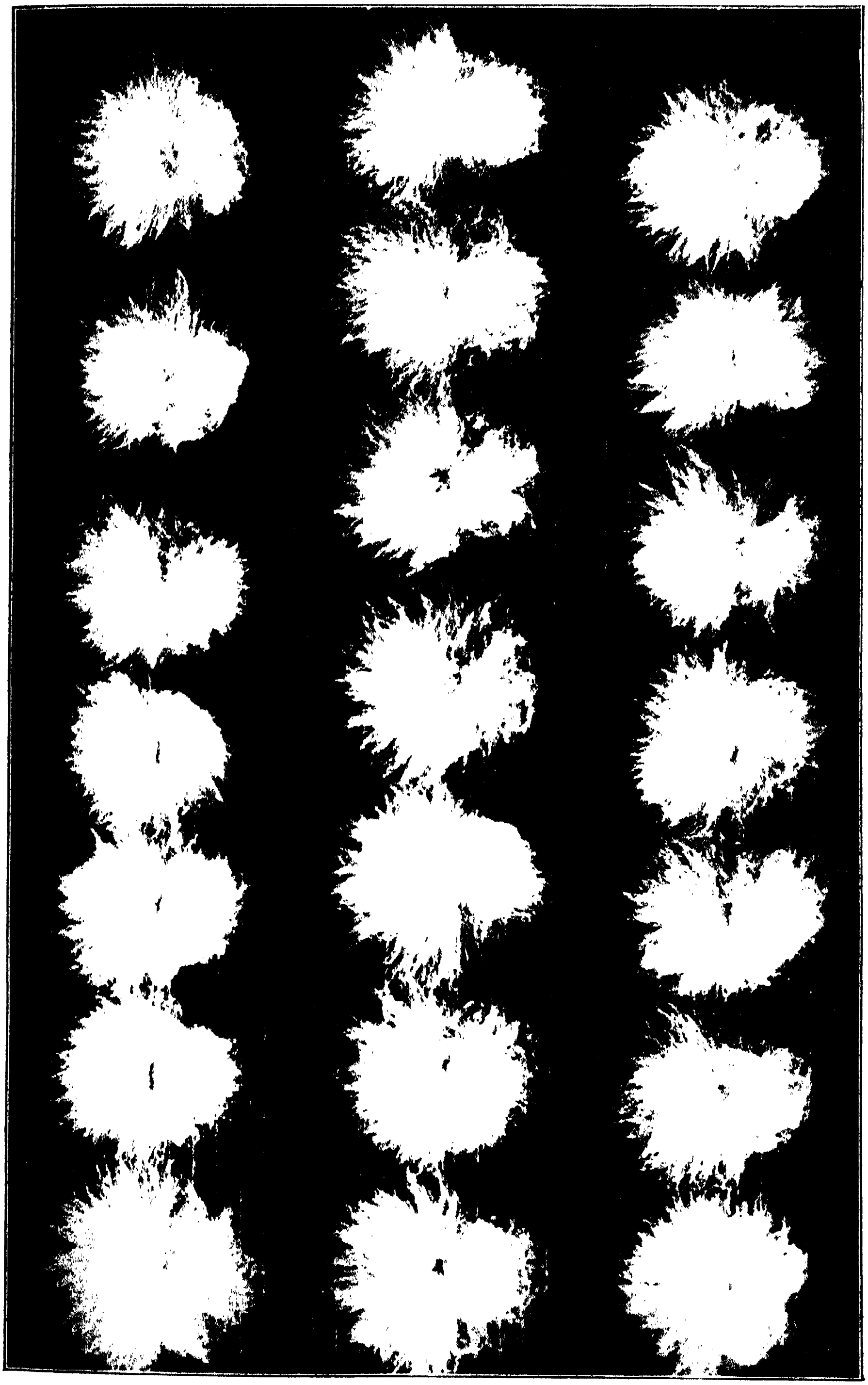
Fig. 1. Variations in the length of fibre on different seeds in the same boll.

Fig. 2. Fibre length on second seeds of each of the three locks of a boll.



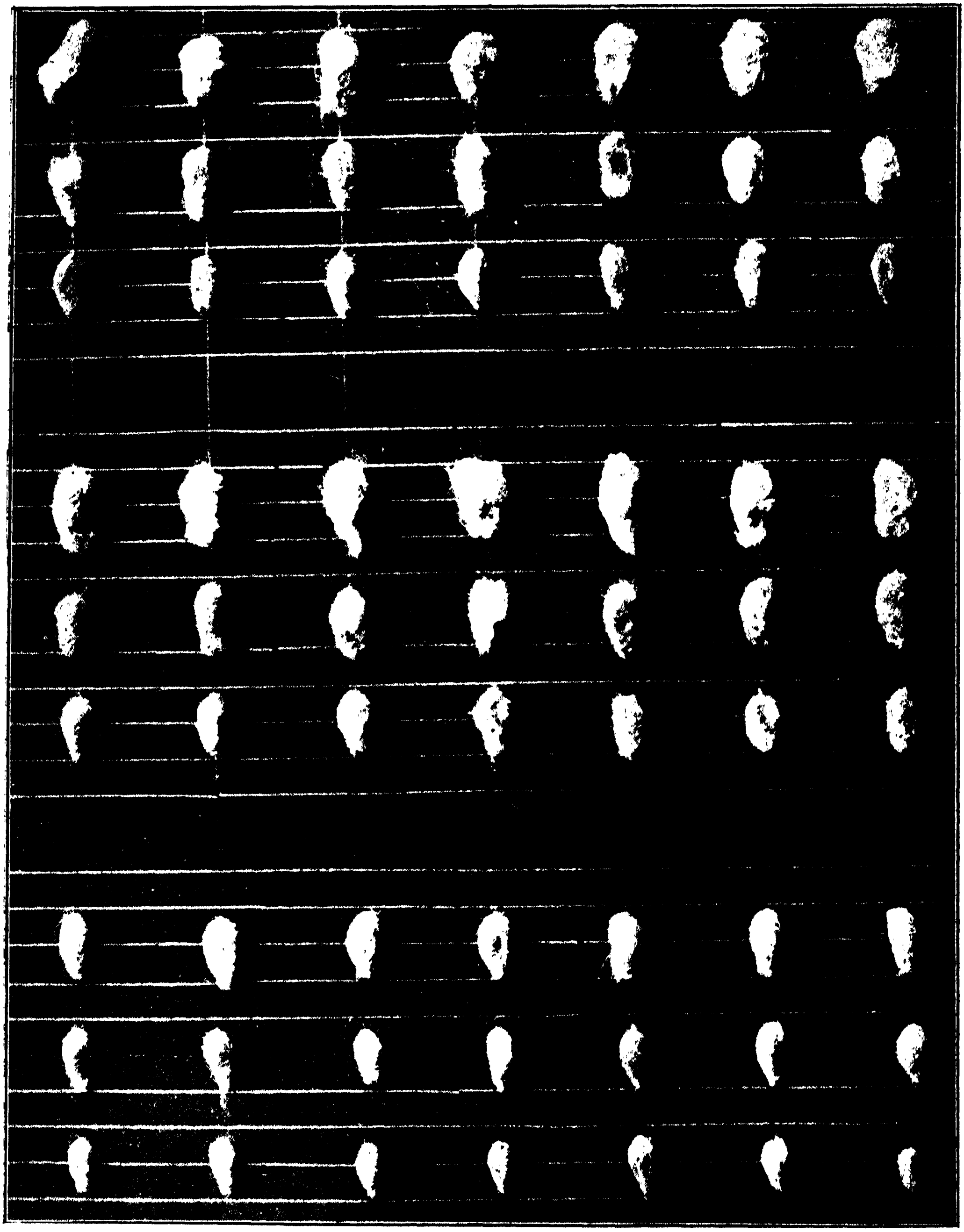
FIBRE LENGTH OF REMAINING SEEDS OF THE LOCK, THE SECOND SEED OF WHICH IS SHOWN IN FIG. 2 ON PL. XXXI.

PLATE XXXIII.



First row. Second seeds of a number of locks of different bolls of the same plant.
Second row. Second seeds of a number of locks of different bolls of a sister plant.
Third row. Second seeds of a number of locks of different bolls of another sister plant.

PLATE XXXIV.



THREE SAMPLES OF SEEDS FROM THREE SELFED PLANTS. FIRST AND THIRD ROWS IN EACH CASE SHOWING THE BIGGEST AND THE SMALLEST SEEDS PICKED FROM THE SAME SAMPLE TO ILLUSTRATE RANGE OF VARIATION.

show an appreciable change in favour of improvement. In the cotton survey series 40 per cent. of the plants examined fell below the level 33—34 while in this series there was not a single plant which went below 33 per cent.

With a veiw to study the relation of length and ginning percentage in a different manner, a number of series composed of pure lines of many crosses in their various generations were isolated and statistically examined and their co-efficients of correlation worked out. As has already been stated, the ginning percentage is a compound character composed of three factors, *viz.*, the number of fibres per seed, weight of the individual fibre, and weight of the seed. The length of the fibre is a relatively simple character, but still considerable variation exists between the length of the lint of different bolls of the same plant (Plate XXX). Again within the same boll, very often, slight variations in length of lint are perceptible between different seeds (Plate XXXI, fig. 1). Therefore in order to make the samples uniform for comparison purposes, the second seed of the upper end of a lock is taken, combed and put on a ruled black paper, the central line of which is red, and there are five white lines on both sides of the central red line, each five millimeters apart. The seed is put on the red line and the combed fibre spread upwards and its length is read off in units of two millimeters and we get a figure which generally serves as an index for the plant. It may be useful to illustrate the method of selection of the seed for a sample a little more closely. A boll was picked at random from the produce of a single plant and it had three locks. The second seeds of each lock were taken out, combed and put on paper (Plate XXXI, fig. 2). The remaining seeds of those three locks were also combed and put on black paper in the same way. They are shown in Plates XXXI and XXXII. In order to take a more extensive view, the second seeds of a number of locks of different bolls of the same plant as well as of other two sister plants were picked at random, combed as above, and are shown in Plate XXXIII. In the upper row of Plate XXXIII is a decided difference. The other two rows also show the second seeds only taken from the different bolls of two sister plants of the same parentage as used in other illustrations. The samples of the second seeds, though they decidedly exhibit slight variations, yet, for practical purposes, are always taken and used as a standard for mutual comparison of samples. The seeds also furnish the same degree of variety in size. Three samples illustrated in Plate XXXIV are taken from three selfed plants and the biggest and the smallest seeds have, of course, been picked to show the range of variation. The average sample, however, is represented by the size of seeds on the middle line in each case. Variations if closely observed are found, as everybody knows, in almost all parts of the plant, because no two are ever exactly alike. We are therefore forced to deal with averages in all classes of biological variation.

After the sample is taken and put on paper the whole produce of the plant is ginned with a small gin, and after weighing the seed and the lint separately the ginning percentage is calculated. By plotting the figures thus obtained both

for length and ginning percentage in a particular series we get the following table :—

TABLE III.

Showing length of fibre and ginning percentage in the progeny of a cross.

Length in mm.	*Ginning percentage*								
	33	34	35	36	37	38	39	40	TOTAL
20 . .	..	..	..	1	2	3	..	3	9
22 . .	..	2	2	10	14	11	3	1	43
24 . .	..	2	2	5	7	5	1	..	22
26 . .	2	..	4	..	..	..	..	..	6
TOTAL .	2	4	8	16	23	19	4	4	80

On calculating the co-efficient of correlation the value of ' r ' is

$$r = \pm 0{\cdot}37 = 0{\cdot}06$$

The plants used in this determination are the result of a cross made long ago and it may be interesting to have its full history given.

CHART NO. I.

Showing the history of the cross of which the length and ginning figures are given in Table III.

Year					
1905	*Gossypium arboreum* 24 mm. 25 G. P.	× ↓	*Gossypium neglectum roseum* 18 mm. 38 G. P.		
1913		F_8	*Gossypium indicum* 25 mm. 26 G. P.	× ↓	*Goss. cerneuum* 15 mm. 43 G. P.
1914		F_9		F_1	
1915		F_{10}		F_2	
1916		F_{11}		F_3	
917	A plant having 22 mm. 38 G. P.	F_{12}	× ↓	F_4	A plant having 22 mm. 30 G. P.
1918			F_1		
1919			F_2		
1920			F_3		
1921			F_4		
1922			F_5		
1923			F		

A little explanation here may perhaps be necessary. In 1905 a plant of *Gossypium arboreum* with 24 mm. length and a ginning percentage of 25 was crossed with *Gossypium neglectum roseum* having 18 mm. length and a ginning percentage of

31. In its twelfth generation in 1917 a plant from this cross possessing 22 mm. length and 38 ginning percentage was again crossed with a plant which itself was also the result of a cross of two different types, *Gossypium indicum* (yellow) having 25 mm. length and 26 ginning percentage and *Gossypium cerneuum* with a length of only 15 mm. but ginning at 43 per cent., originally made in 1913. In 1917 in its fourth generation this latter cross gave a plant which had 22 mm. length and 30 ginning percentage. It was this plant which was crossed in 1917 with the abovementioned one which was in its twelfth generation. The progeny of this cross was carried further when in 1923 in its sixth generation it gave 80 plants which have been tabulated above. Other economic aspects of this cross such as habit, maturation period, and fertility, etc., have no concern with the question under consideration. These plants are in their sixth generation and it may be interesting to see how the previous generation did as regards the relation of their lengths and ginning percentages. Figures collected from the F_8 generation were similarly dealt with and their co-efficients of correlation along with F_6 shown already are given below :—

Year	F generation	No. of plants	Co-efficients of correlation
1920	F_3	44	$r = \pm 0{\cdot}72 = {\cdot}04$
1921	F_4	81	$r = \pm 0{\cdot}49 = {\cdot}05$
1922	F_5	223	$r = \pm 0{\cdot}25 - {\cdot}06$
1923	F_6	80	$r = \pm 0{\cdot}37 = {\cdot}06$

The greater number of determinations as there are in F_5 appear to bring down the high correlation figure $\pm$ 0·72 to $\pm$ 0·25, nearer the general average found in other cases in different series.

In the abovementioned instance the number of plants was composed of the offspring of the sister plants raised from a common parent. In order to more closely restrict the degree of variation another set of plants was taken, examined, and calculated. Their history is given below :—

CHART NO. 2.

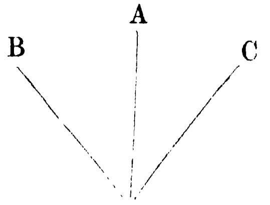
Showing the history of a cross the co-efficients of correlation for which were determined.

Year				
1905	*Gossypium arboreum* 24 mm. 25 G. P.	× ↓	*Gossypium neglectum roseum* 18 mm. 38 G. P.	
1916	A plant 22 mm. 38 G. P.	F_{11}	×	*Gossypium cerneuum* 15 mm. 43 G. P.
1917			F_1	
1918			F_2	
1919			F_3	
1920			F_4	
1921			F_5	
1922			F_6	
1923			F_7	

It would be found here that one of the parents was the same as shown in the previous chart, but the other parent instead of being the result of a crop, as in the former case, was a pure form of *Gossypium cerneuum.* The cross was made in 1916 and in 1921 F_5 was raised. The co-efficient of correlation when worked out in F_5 was found to be very low, or rather nil, as the probable error was higher than in the previous case shown in Chart No. 1.

Year	Generation	No. of plants	Value of r
1921	F_5	31	r= ±0·22=·09

A number of single plant cultures were then selfed from this collection, of which the co-efficient of correlation is given above, and the determination of length and ginning percentage for each case was made separately. The length of fibre was calculated in a slightly different manner. Three readings A, B and C of the fibres of each sample of the second seed of a lock were taken. The first reading A was of the central position, and the other two B and C were of each side of the spreading halo of the fibres. An average of all the three readings was used in the comparison of length in this series.



The co-efficient of correlations of the progeny of different plants of the same culture were found as follows :—

Year	No. of plants	Value of r
1922 (*a*)	49	r= ±0·21=·05
„ (*b*)	41	r= ±0·30=·09
„ (*c*)	27	r= ±0·45=·10
„ (*d*)	34	r= ±0·03= —
„ (*e*)	51	r= ±0·12=·09

In addition to the above, a few more determinations of length and ginning percentage were made on plants raised pure from other series of a different cross. The values are given below.

Year	No. of plants	Generation	Value of r
1917	70	F_{12}	r= ±0·19=·07
1918	237	F_{13}	r= ±0·18=·04
1919	152	F_{14}	r= ±0·05= —

If we consider the resultant values of r collectively for all the series narrated here we find a negative correlation of a very small magnitude, say, about $\pm 0{\cdot}27$. Leaving the two exceptional cases in which the values are almost at par, the range appears to fluctuate between $0{\cdot}18$ and $\pm\ 0{\cdot}72$ which mostly could be masked if the minus side of the probable error were also taken into consideration.

This method of ascertaining the correlation among the two characters standing wide apart in their mutual relation and constituents, as already explained, is admittedly defective. The ginning percentage is decidedly most influenced by the weight of the lint present on the seed. The weight of lint depends chiefly on the number of fibres arising from a seed and also to some extent on their length. It appears that the density, *i.e.*, number of fibres per given area, is greater in high ginning varieties than in the low ginning ones.

A series of figures indicating this fact has been selected from a number of determinations made by Dr. Leake and the author several years ago.

Ginning below 30 per cent.

G. P.	Volume of the seed in cm.	Number of fibres per seed
24·2	52·8	2,461
24·9	39·5	2,143
26·2	50·5	3,899
27·5	54·8	3,087
27·7	49·4	2,955
27·9	71·5	5,813
28·5	42·0	2,608
28·8	50·9	3,128
29·1	44·5	3,252*
29·9	42·3	3,626

Ginning between 30 and 40 per cent.

30·6	64·2	4,590
31·1	49·9	4,212
32·2	51·5	4,618
33·8	55·1	4,157
34·6	43·0	4,158
35·3	47·7	4,757
35·7	46·6	4,317
35·9	39·1	4,333
36·6	51·0	4,677
37·4	40·6	4,268

Ginning above 40 per cent.

G. P.	Volume of the seed in cm.	No. of fibres per seed
40·7	45·5	6,144
41·8	40·0	5,268
42·0	51·0	6,158
42·4	53·0	5,286
42·4	50·8	5,818
42·6	48·9	6,305
42·9	55·8	6,877
43·4	41·8	6,269
44·1	53·1	7,321
44·3	46·4	6,995

It can be seen here that in the three sets of figures the higher the ginning percentage, the greater becomes the number of fibres per seed. A full range from the lowest to the highest ginning percentage is given here. It should also be mentioned that the samples ginning above 40 per cent. and giving the highest ginning values and the greatest number of fibres per seed, were entirely derived from the Aligarh White-flowered type which has the shortest staple in all the cottons of these provinces, about ⅝th of an inch. Other samples mostly consisted of plants possessing long and good staples which were found in the course of experimental work on cottons at Cawnpore. Of the pure types possessing longest lengths the most remarkable is *Gossypium arboreum*, figures for which are pointed out by a star in the first part of the statement.

High ginning cottons, therefore, generally appear to have a closer clustering of their fibres on the surface of the seed than the low ginning ones, in which the individual fibres grow comparatively further apart. Different degrees of dispersions of the fibres in a given unit area also appear to be further associated with the length of the fibre, which is shorter in close and compact growing varieties, than in the loose and sparsely arranged ones where the fibre has a longer length.

The size of the boll and the number of seeds per boll in the different types of cotton put a limit on the amount of space which can be available inside the fruit for the lint to grow. Whether a given type having a greater density, higher ginning percentage, and short length can be worked up by crossing or any other method to produce a longer staple by enlarging the inner cavity of the boll, either by reducing the number of seeds per boll, or by increasing the size of the boll, is a question which could be answered only by further continuing the work. Some of the physiological and meteorological influences operating on the cotton plant during its growth and development, will also have to be taken into consideration, because some preliminary data collected in this direction clearly appear to indicate considerable degree of variations resulting from these environmental agencies.

Summary.

In the course of experimental work on Indian cottons at the Botanical Farm, Cawnpore, both selection and hybridization methods were applied to the various types in order to examine the inheritance of ginning and staple characters. Selection method was employed on a fairly extensive scale and covered three districts extending to an area of several thousand square miles, and almost every village that grew cotton was visited and many thousand samples were examined each year. Selections from these samples were grown on the farm and the progeny was studied chiefly in respect of the ginning percentage and staple length. The figures as far as they pertain to these two characters are shown in the form of a table in the text. In the year for which figures are given, there were certain groups which appeared to be an improvement on the general collection, but in later years they tended to decline in one respect or the other and the combination of high values for both characters thus appeared to be unstable. There was sufficient material in the collection which could be improved by crossing, if hybridization methods were applied. As regards the ginning percentage some improvement over the general average of 33 per cent. was also found, but wherever higher values both for ginning and lint length were discovered, they ultimately proved to be transitory.

In the hybridization series where different types possessing characters of lint and ginning percentage to a desirable degree were crossed together, and purified for these characters, the results were found to be much better in the subsequent generation. After F_3 the range of variation in the combination, selected for higher values of length and ginning percentage, gradually appeared diminishing, and the general level of the groups selected for these characters appeared to remain higher from generation to generation than in the other corresponding series. In the selection series 40 per cent. of the plants examined fell below the level 33—34 per cent., while in the hybridization series there was not a single plant that went below 33 per cent.

In addition to this general method of comparison, the plants were also subjected to statistical examination and the co-efficient of correlation for ginning percentage and length of lint was worked out. As already stated, the application of this method may be considered unsound in this case because it involves the comparison of a simple character with a compound one.

As far as, however, the comparison has been made, it appears to point to the same conclusion that the correlation is negative and that as the ginning percentage increases the length of the staple decreases. The co-efficient of correlation obtained in different determinations averages at $\pm 0{\cdot}27$, and the small magnitude indicates slightly partial correlation.

The number of fibres on cotton seed is also a decidedly important factor which influences appreciably the ginning values in cottons. Determinations of the number of fibres per seed were made, covering a range of different types of cotton. Figures given above show that the ginning percentage increases as the number of fibres per

seed rises. This also appears to be confirmed by certain cotton varieties found in various parts of India to-day. *Gossypium roseum* and *Gossypium cerneuum* possess the shortest lint of all the Indian forms of ***Gossypium***, while they are also characterized by having the highest known ginning percentages in the cotton world. *Gossypium herbaceum* and *Gossypium indicum* to which the greater portion of the long staple cottons of India belong, gin at 32 and 28 per cent. respectively. It is admitted that other characters of plant such as the size of boll, size of seeds, number of seeds per boll also contribute in influencing the ginning percentage. Studies in this direction, preferably by hybridization methods, may be a profitable line of investigation, as they would throw some light on the ultimate factors which determine the inheritance of the representative genes of these two characters at the time of chromosome division and gametic segregation.

Briefly tabulated, the points are :—

(1) By the selection method the length of the staple and ginning percentage do not permanently retain their high values. Some increase in one or the other direction is possible but a definite limit in the combination of their high values is imposed by pure line selection methods of improvement.

(2) The hybridization method provides better means for effectually retaining the combination at the high value of the two characters of length of fibre and ginning percentage, and for this reason the crossing method appears more hopeful.

(3) A limit in the combination of two characters of the length of fibre and the ginning percentage is decided. (It may be possible to produce a cotton ginning 38 per cent. and having lint capable of spinning 22s.)

(4) The degree of the closeness of cotton hairs on the surface of the seed increases with the ginning percentage, the number of fibres per unit area being greater in high ginning ones and fewer in low ginning ones.

THE RELATION BETWEEN NET ENERGY VALUE AND DIGESTIBILITY.

BY

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INTRODUCTORY.

At the present time the net energy value of a food is by far the most important criterion of its nutritional value. The subject has already been touched upon in a previous article by the writer, but for the purpose of the present paper certain particular points require emphasis and on this account an elementary introduction and some recapitulation are necessary.

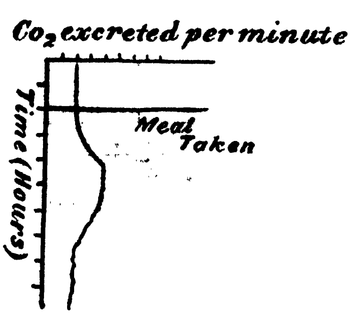
At the outset it has to be realized that the animal body is a machine which never ceases to perform work. Even a bullock at rest is constantly doing internal work connected with respiration, blood circulation, and so on. The energy required for this essential work and for any additional external work is obtained by the oxidation of combustible substances within the body. The body avails itself of the potential chemical energy of organic substances by oxidizing them, exactly as we might use the pent up energy in wood fuel by burning it. That such oxidations take place in the body is proved by the CO_2 which is excreted in the breath. The CO_2 breathed out from the body is a very considerable quantity. It may easily amount to 7 lb. a day in the case of a resting bullock.

A starving or underfed animal loses weight. Its store of fat and flesh is depleted. But there is no evidence that fat and flesh are excreted as such by the animal. The excretions from the body take place through the breath and urine and the excreted substances are oxidation products. This proves that the losses of body fat and flesh are due to the oxidation of these substances within the body. In this case the animal is oxidizing its own body substance to provide the energy needed for carrying on the essential internal work. When food is given and the ration brought up to a certain standard, the animal neither gains nor loses weight. Oxidation must still be proceeding to provide the necessary energy but the material losses are now balanced by the food assimilated. In other words, the food provides the energy, and it does not concern us here whether the effect of the food is direct or indirect. We learn from this that one of the functions of food is to provide energy. It is by no means the only function, but incomparably more material is required to meet the energy demand than for any other purpose. Thus it comes about that we have to value our foodstuffs primarily according to the energy they provide.

The gross energy of a foodstuff is simply its fuel value and is measured by determining the amount of heat it emits when burnt. This figure is of little use, however, because only part of the food is digested. Some of the gross energy is lost in the fæces. From digestion experiments this loss can be allowed for and a figure

is obtained for the amount of energy actually assimilated. All the assimilated energy is not utilized either because the oxidations taking place in the body are not quite perfect. Some of the excreted products in the urine and breath are capable of more complete oxidation. By examining the excreted products the losses due to this cause can be allowed for and we obtain what may be termed the utilized energy. The tale of the losses is, however, not complete yet. An item with which this paper is intended to deal remains to be considered.

Let us examine the CO_2 excretion of an animal after it has had a meal. The accompanying graph shows diagrammatically the effect of food consumption upon the excretion of CO_2 from the lungs. We know that CO_2 excretion is practically equivalent to and a measure for bodily energy expenditure. The graph shows that consequent upon food consumption there is a great increase in energy expenditure. This is due partly to the mechanical work of mastication, etc., and partly to increased cellular activity caused by the stimulus of food. It has to be noted that the extra expenditure of energy associated with food consumption does not help the animal to carry on its vital functions at all. It is entirely additional expenditure unavoidably associated with the act of eating. To get the true net energy value of a food the waste of energy due to this so-called work of digestion has to be deducted from the utilized energy. The measurement of the work of digestion has been carried out for a few foodstuffs in America and Germany. The process is costly, laborious, slow and requires elaborate apparatus and the very highest scientific and technical skill. From the few determinations which have been made, Armsby in America has calculated the net energy value of a considerable number of foodstuffs. In making these calculations he employed analogies and utilized his great knowledge of foodstuffs. Kellner in Germany has carried out similar calculations for European foodstuffs. It remains now to enquire whether these valuable figures are applicable to our Indian foods and Indian cattle.



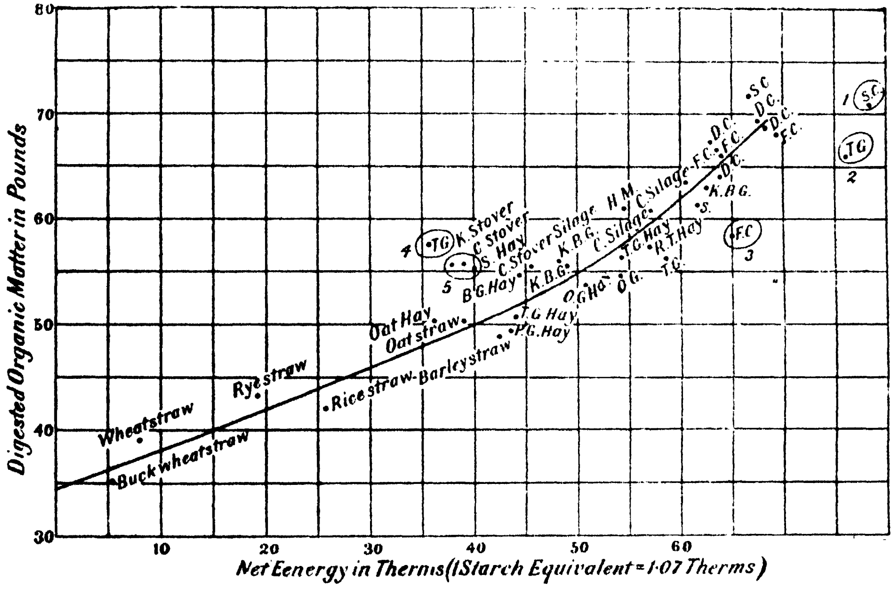
A long series of careful tests recently completed at Bangalore show that the figures do not hold good for some of our roughages. The situation therefore is this: We are not yet in a position to carry out the elaborate net energy determinations mentioned above, and it has been proved in the specific case of an Indian foodstuff that the American figures do not hold good. In this dilemma the writer undertook to examine Armsby's net energy value tables. The results of this examination are described below.

THE RELATIONSHIP BETWEEN DIGESTIBILITY AND NET ENERGY VALUE.

Let us consider the case of two foodstuffs, the one yielding 50 lb., the other only 25 lb. of digestible organic matter per 100 lb. of dry substance. The energy derived

from the first will be double that derived from the second. On the other hand, the mechanical work of digestion will be almost identical. In other respects, too, the effect upon the animal will not be dissimilar though the stimulating effect of the more digestible food might possibly be twice as great as that of the less digestible substance. For these reasons it may be surmised that the losses of energy associated with digestion will not be in the proportion of 2 to 1. The more digestible food is likely to yield its nutriment with relatively less expenditure of effort. Its net energy value will therefore be more than double that of the less digestible food. Considering a series of foodstuffs we should accordingly expect a relatively rapid increase of the net energy value with increasing digestibility.

To determine the rate of increase of net energy with increasing digestibility, data given by Armsby and by Henry and Morrison, respectively, have been united. The net energy values have been taken from Armsby. The digestion of organic matter has been calculated from Henry and Morrison's extensive data. Both sets of figures have been reduced to the dry basis. In this way data have been procured for the net energy value and the digested organic matter per 100 lb. of dry substance for a number of typical American fodders. The results are shown in the accompanying graph.



NET ENERGY VALUES AND DIGESTIBLE ORGANIC MATTER PER 100 LB. DRY SUBSTANCE.

The foodstuffs for which abbreviations have been employed above are :—
D. C. (Dent Corn), F. C. (Flint Corn), S. C. (Sweet Corn),
S. (Sorghum), Corn Silage, Corn Stover, Kafir Stover.
H. M. (Hungarian Millet), K. B. G. (Kentucky Blue Grass),
T. G. (Timothy Grass), B. G. (Brome Grass), O. G. (Orchard Grass),
R. T. G. (Red Top Grass), P. G. (Prairie Grass).

A number of points in this graph are noteworthy. It may be noted in the first place that the regularity in these figures has been revealed by reducing all foodstuffs to the dry basis. The most important fact which is shown by the table is that, with a few notable exceptions, the points representing the foodstuffs lie very near a line. In other words, there is a close relationship between digestible organic matter and net energy value. It will be noticed, too, that the net energy value increases more rapidly than the digestibility. For instance, with 50 lb. of digestible organic matter per 100 lb. of dry substance the net energy value is 40 therms. If the two quantities increased in the same proportion, 60 lb. of digestible organic matter should yield 48 therms. Actually they yield much more (57·5 therms).

Some remarks are required regarding the extreme deviations from the line. Nos. 1 and 2 are peculiar products. They represent very immature herbage containing 90 per cent. moisture. No. 4 is also peculiar in being an exceptionally mature grass, consisting of 46 per cent. dry substance when cut. The list contains no other grass sample which had been cut at such a dry stage. These examples show that with advancing maturity the net energy value obtained from a given amount of digestible organic matter decreases very considerably. It is an object lesson in fact. No. 5 includes sorghum hay, corn stover and Kafir stover. These fodders are undoubtedly hard to eat and their net energy value is consequently low when considered in conjunction with their digestibility. This important class of foodstuffs cannot be incorporated in the graph. It is interesting to notice, however, that fresh green sorghum takes up a normal position with the green corn fodders. Figures for the legumes show that they all diverge in a manner similar to the dry sorghum. To avoid overburdening the graph the legume figures have been omitted. The next important point to note is that practically no difference exists between dried hays and fresh grasses. They all fall near the same line, the net energy values bearing in all cases the appropriate proportion to the digested organic matter. To avoid misconception, however, it is necessary to state here that this conclusion has no bearing on the debated point regarding the relative digestibility of fresh grass and the corresponding hay. The graph merely shows that both grasses and hays have net energy values which are related identically to digestibility.

Finally, a word must be said about the minor deviations. They are not errors but represent differences in the work of digestion, which quantity was estimated by Armsby. These estimates made by an eminent authority are undoubtedly significant, if not absolutely exact. There is every reason to suppose that the complex phenomena grouped together under the term work of digestion are characteristically peculiar for each foodstuff. The points therefore cannot be expected to fall along a regular line. We do see, however, that on the whole they are closer together than might have been expected, and that the graph may be employed for making rough estimates of the net energy values of foods.

The actual case which led the writer to this enquiry will make clear the great value of this graph. The average of American tests shows rice straw to yield 42 lb.

of digestible organic matter and 25·5 therms net energy per 100 lb. of dry substance. The average of many closely agreeing results obtained at Bangalore shows that 100 lb. of our dry rice straw yield 49·9 lb. of digestible organic matter. Clearly its net energy value must be greater than 25 therms. What value is to be assigned to our straw? The graph shows that its net energy value is about 40 therms. In this particular case it happens that Armsby's procedure for calculating the net energy value is available. Calculated thus the result is 38 therms, which agrees with the graph value as well as could be expected. The graph is highly interesting in another way. It shows at a glance whether the work of digestion of a foodstuff is abnormally high or low. Food substances which involve a high work of digestion lie above the line, those which have a low work of digestion associated with them fall below the line. Important enquiries are suggested by the anomalies revealed in this graph.

CONTROL OF THE COCONUT CATERPILLAR (*NEPHANTIS SERINOPA*) BY ITS PARASITES*.

BY

RAO SAHIB Y. RAMACHANDRA RAO, M.A., F.E.S.,

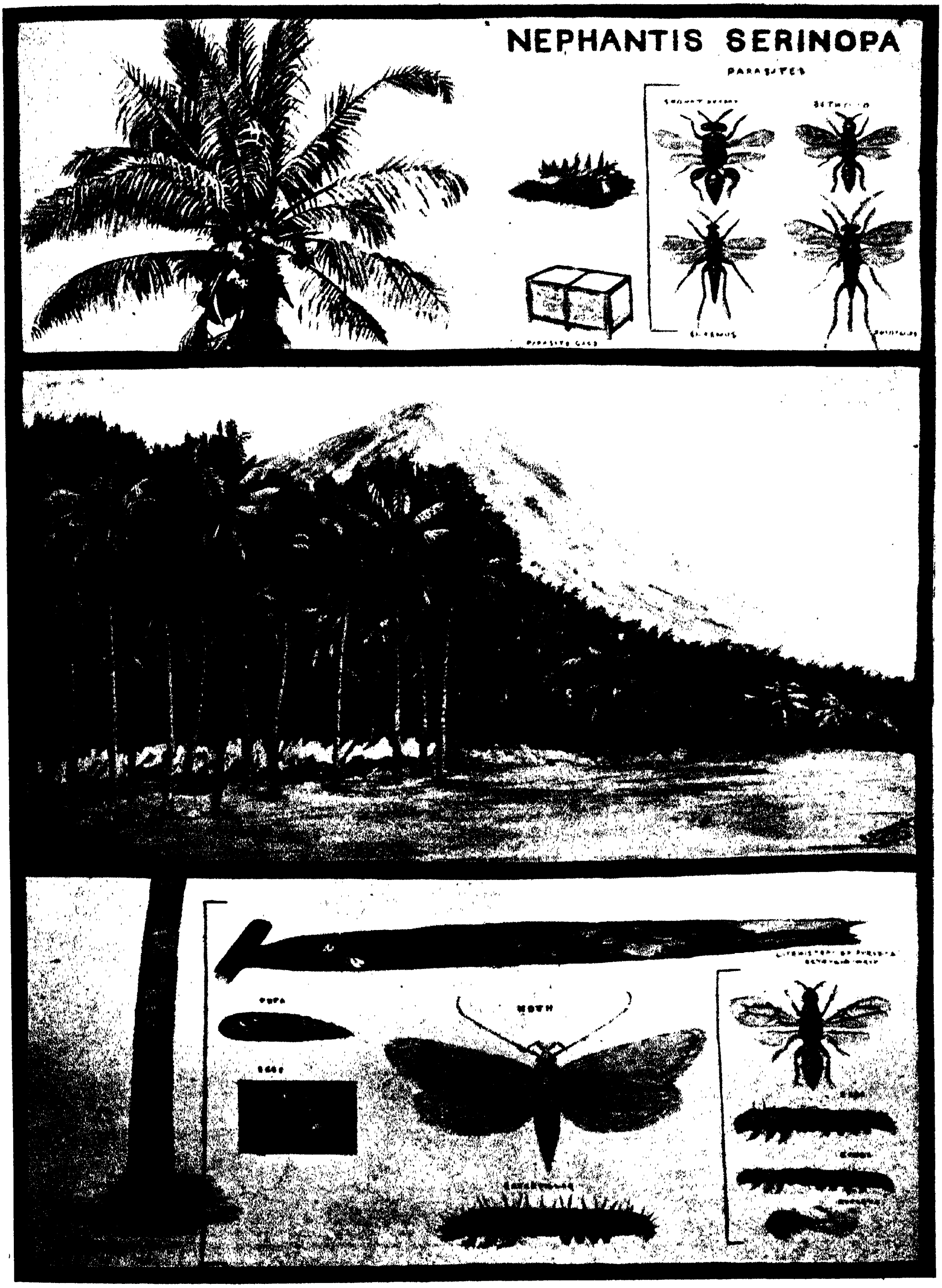
Offg. Government Entomologist, Coimbatore.

Nephantis serinopa, or the "black-headed caterpillar" of coconut, is a fairly common pest of various palms in South India. It has been found attacking, besides the coconut, other palms, such as the palmyra, the talipot, the wild date (or *toddy*) palm and certain imported species of Palmaceæ. The caterpillar is cylindrical in shape, about an inch in length when full-grown, and is striped with narrow purplish longitudinal lines. The head and the prothoracic shield are dark reddish brown, while the mesothoracic segment is dark brown, so that to a superficial observer the caterpillar is conspicuously darker anteriorly, whence its popular name of "the black-headed caterpillar." It usually lives gregariously on the lower surface of leaves under cover of galleries of chewed fibre and excreta bound together with strands of silk. When mature, the caterpillar constructs a tough cocoon of silk and frass in a portion of the galleries and pupates inside. The moths emerge in about 10 days. Female moths may lay 300 to 400 eggs each either on the leaves themselves or, as is much more common, amongst the frass of galleries in groups of 3 to 20 or sometimes more. The eggs are about ¾ mm. long, elliptical, somewhat flattened, slightly reticulated and yellow with a pearly sheen. They hatch in 4 to 5 days, and the young caterpillars begin at once to prepare little galleries in continuation of the old ones, so that in a short time the whole leaflet is consumed and turned into parchment. In cases of bad attack the whole coconut palm looks as if it had been burnt.

THE OUTBREAK AT MANGALORE.

This caterpillar came into sudden prominence towards the close of 1921, when a petition signed by numerous citizens of Mangalore reporting a very severe outbreak of this pest, was received by the Government Entomologist, Coimbatore. Previous to this report the pest was unknown on the West Coast north of Cochin. From enquiries made it was ascertained that the pest had originated from certain consignments of coconut seedlings received by rail from Kayankulam in Travancore, and naturally the first attacked palms were those around the railway station and the

* Paper read at the Indian Science Congress, Bombay, January 1926.



A BADLY INFESTED COCONUT TREE AND VARIOUS PARASITES.
(The inset is of a badly attacked garden at Tudiyalur near Coimbatore.)

terminus of the branch to the harbour. In 1922 most of the infected trees were treated by cutting and burning, with the voluntary co-operation of the great majority of the citizens, but there was a certain number of citizens who would not allow their palms to be operated, and therefore the Government of Madras had reluctantly to bring in the aid of the Pest Act from January 1923. Though generally relief was experienced after one round was finished, it was noted that the treated palms almost always showed a re-infestation within 4 to 6 months, so that a re-clearing became necessary. Moreover, since the provisions of the Act allowed the garden owners to clear their trees themselves without the supervision of the Pest Act staff, it was not possible to ensure that the infested fronds were properly destroyed by burning. The fronds were thus often stolen and transported from place to place either on carts or by boats, so that eventually by 1925 the pest was found to have spread to many distant places in South Kanara through such agency. The most remarkable instances were the discovery of isolated cases of infestation at Gangolly, the port of Coondapoor—60 miles to the north of Mangalore—and at Kalnad at the mouth of the Chandragiri river 30 miles to the south. In both cases the agency of the large fishing boats plying on the sea in fair weather is to be suspected.

Before long, it began to be felt that the measure of cutting and burning the infested fronds would never by itself be able to solve the problem entirely. For, even supposing that the infested fronds were properly disposed of by burning and thereby destroying the eggs, larvæ and pupæ in the galleries, it is evident that the moths that might be at large at the time of cutting would not thereby be affected, and these are at liberty to fly to other palms or to fronds higher up, lay eggs and bring about a fresh infestation. Spraying with stomach poisons like arsenates or with repellents like kerosene or crude oil emulsions was found impracticable under existing Indian conditions, the palms to be dealt with being generally 30 to 50 feet high.

Natural Enemies.

In these circumstances, the pest was carefully examined in 1922 and 1923 to see if there were any natural enemies present at Mangalore. The presence of a large Chalcid wasp (*Stomatoceras sulcatiscutellum*) breeding in the pupæ of the moth was noted, and in addition also the presence in very small numbers of a Carabid grub (*Callida splendidula*) feeding on the caterpillars.

It was, therefore, recognized that by an indiscriminate burning of all cut fronds, the natural enemies were being destroyed along with the pest itself, and endeavours were, therefore, made in 1923 and 1924 to prevent this and to save the parasites by the provision of large parasite cages, located in the chief centres of infestation at Mangalore. These cages were fitted with sides of wire gauze of 10 to 12 mesh and were designed to hold large numbers of cut fronds known to contain specimens of parasitized pupæ; and when in the course of two weeks, moths and parasites emerged from the leaves, the parasite wasps were able to escape through the wire gauze while

the moths were retained inside. In the course of these two years, a certain amount of amelioration was perceptible, though, however, not to such a degree as to bring appreciable relief.

Parasites in the East Coast Districts.

Sometime after the outbreak at Mangalore had been brought to the notice of the Agricultural Department, a report of a similar infestation was received from the Salem Zemindari in August 1922. An examination of specimens of infested leaves received, revealed the presence of the white cocoons of a Braconid parasite among the galleries. On a personal examination of the garden a month later, it was found difficult to collect even a single specimen of the caterpillar, even though most of the leaves had been badly damaged. A visit to the same garden the following year confirmed our assumption that the pest had been completely checked by its parasites. In March-April 1924 a coconut garden which had been severely damaged by this pest was observed at Ayodhyapatnam—six miles east of Salem town. During a visit paid in June and again in July 1924, the presence of fairly large numbers of parasites (the Bethylid and the Braconid), attacking the pest in the larval stage, was noted, and this was taken advantage of for sending consignments of infested leaflets by rail to Mangalore for introducing these parasites there. When the garden was visited next in November 1924, and again in April 1925, not even a single specimen of the caterpillar could be seen. Similar cases of complete control by parasites were noted at Tirukoilur, Palur and Madurantakam, and these instances of such natural control suggested the idea of their introduction into Mangalore.

Parasites of Nephantis in the plains of South India.

Four different species have been noted in most of the places examined, one of which attacks the pupal stage of the pest, while the other three attack the larval.

1. *Stomatoceras sulcatiscutellum* is a Chalcid wasp of medium size, rather thick set, black with a few yellow bars on the legs. It feeds on sugar water in captivity. It searches the cocoons among the galleries and after piercing the walls of the cocoon and the pupal cuticle with its sharp ovipositor deposits an egg inside the pupa. The grub that hatches consumes its contents and turns into a pupa inside the pupal shell. The wasp emerges biting its way out cutting a round hole through the pupal shell. The parasitized pupa can be distinguished from a normal one by its being irresponsive to stimulus and by developing black streaks intersegmentally.

This parasite has been found subject to the attacks of a hyper-parasite—a Chalcid —of sub-family Eurytomidæ. It has been noted at Coimbatore, Samalkota and Salem.

2. *Perisiersla* sp.—*Fam. Bethylidæ.* This is a black wasp of small size—measuring about 3 to 5 mm. in length. It is rather flattened, has rather

short legs, and looks more or less like an ant endowed with wings. It is very active and rather pugnacious. Two or more may join together to mob a caterpillar, kill it and feed on its juices. The female generally searches for a freshly prepared cocoon of a caterpillar, and forces its way in and, after paralysing it, lays slender, elongate eggs, 8 to 14 in number, on its body. The eggs hatch in 24 to 36 hours and the grubs feed on the juices of the caterpillar and become full grown in about three days. They then prepare rather loosely woven silken cocoons of dirty brown colour —which are generally grouped together—and pupate inside. The adults emerge in about eight days. The wasps are fairly strong fliers.

In certain cases, the Bethylid may also attack and oviposit on fairly large caterpillars found free in the galleries and less frequently even on small caterpillars—in which case, however, only one egg or two may be laid. A single moth has been observed to lay as many as 143 eggs in the course of 44 days. The life-cycle is fairly short, being about 11 to 14 days. It is on the whole a fairly efficient parasite, and has been noted in most places on the Coromandel Coast.

3. *The Braconid—Apanteles sp.* (?). This is another efficient larval parasite. This wasp is a small one—about the size of the Bethylid, wholly black except for the tibiæ and tarsi of the legs which are partly yellowish brown. The wings are fairly large. The female is armed with a medium-sized ovipositor. The life-history of this wasp is but partially known. The egg and larval stages have not yet been noted, but presumably the egg is oviposited inside the bodies of half-grown caterpillars, the ovipositor being thrust through the galleries for the purpose. The grub is presumably an internal feeder and emerges when the caterpillar has been entirely consumed and constructs its beautiful elongate oval cocoon of white colour in corners of the galleries—the most usual place being along the groove of the mid-rib. The wasp emerges by cutting a circular lid at one end. The whole life-cycle occupies about 10 days.

The wasp feeds on sugar solution and honey water in captivity and has been kept alive for about 8 days.

This parasite has been noted along with the Bethylid in most places in the plains.

The hyper-parasite. Both the Bethylid and the Braconid have been found subject to the attack of a small dark brown hyper-parasite wasp— a Chalcid—in and around Coimbatore. The female oviposits into fresh cocoons of the parasites and its progeny emerge biting characteristic round holes in the sides of the cocoon in about 12 or 13 days. This hyper-parasite has proved a serious hindrance in the process of a natural control of the pest through parasite agency in the neighbourhood of Coimbatore. It is feared that this insect has already been unwittingly introduced into Mangalore in one of the earlier sendings, since an instance of Bethylid cocoons attacked by this wasp has actually been noted at Mangalore.

There is in addition another hyper-parasite—metallic greenish blue in colour—which has been found recently attacking Bethylid cocoons in North Arcot District,

4. *Elasmus nephantidis* (*Fam. Chalcidoidea, Sub-fam. Elasmidæ*). This is another Chalcid attacking the caterpillar. It is a small wasp about 2 to 3 mm. long, metallic blue, with the abdomen reddish brown ventrally. Its body is rather compressed. From a lateral view, the profile of its body is somewhat torpedo-like, being rather narrow and constricted at the head, broadest at the thorax, and gradually tapering posteriorly to end in the pointed ovipositor. The wasp feeds freely on sugar or honey water. The female appears to search for caterpillars in freshly formed cocoons, sting them through the walls and to drop inside 10 to 20 (in one case 41) small, elongate eggs loosely on the body of the victim. The grubs hatch in 24 hours and attach themselves to the caterpillars and suck its juices. They become full-grown in three days and turn into naked pupæ inside the cocoon of the pest. The wasps would appear to emerge in about a week.

This wasp is found mostly on the palmyra palm and rather rarely on the coconut. It has been collected so far from the Districts of Chingleput and North Arcot, and also from the Palghat Taluk of Malabar. It also occurs in Travancore.

Parasite introduction into Mangalore.

The classic instances of successful control of insect pests in America by parasite introduction have mainly depended on the circumstance that the pests concerned were exotic species unwittingly introduced into America without their natural enemies. The American entomologists recognized this fact and toured round the world in search of their parasites—visiting the countries reputed to be the original homes of the pest—and eventually introduced them with results which amply justified their work. So far as Mangalore is concerned, *Nephantis* is an introduced pest, since it had never been noted there till the time of outbreak and three of the parasites commonly found on the East Coast were not found there. The conditions, therefore, appeared to be analogous to those in America. Arrangements were, therefore, made to send consignments of infested leaves with live cocoons of parasites by rail to Mangalore. About 20 parcels were sent during the period of approximately a year in 1924-1925. They were placed inside large parasite cages which prevented the escape of moths while allowing the parasites to fly out. The first indications of the establishment of these parasites at Mangalore were noted in January 1925, and before long the results of their introduction could be seen in the greatly diminished numbers of the pest. Trees in Bolar, Jeppoo, and Bunder—which were the worst affected parts since 1922—have shown remarkable improvement. Trees once severely infested present now a healthy appearance and have begun to yield as usual. There are, however, certain areas in Mangalore and in the newly infested parts of South Kanara, where parasites are not yet present in sufficient abundance. Endeavours are being made to convey the parasites from one place to another within the precincts of Mangalore and outside, so as to effect their rapid spread. The outlook appears, on the whole, to be distinctly hopeful at present.

Team-work among the parasites. One of the reasons why *Nephantis* is successfully controlled in its native areas on the Coromandel Coast appears to be the phenomenon of multiple parasitism. The moth appears to be able to lay at least 300-400 eggs and is thus fairly prolific. Its powers of multiplication are attested to by its serious increase in numbers at Mangalore and elsewhere. Although one of the parasites was from the outset existent at Mangalore, *i.e.*, the pupal parasite—*Stomatoceras*, it proved to be unable to control the pest by itself. It was only when two other parasites were introduced, *viz.*, the Braconid and the Bethylid, that a diminution in the numbers of the pest was noticeable. The secret lies in the fact that these parasites attack the pest at different stages of its growth, so that there is not much of clash of interest or of competition among themselves. The Braconid attacks only young caterpillars, while the Bethylid prefers full grown ones, while *Stomatoceras* parasitizes only the pupa. *Elasmus*, on the other hand, attacks only caterpillars about to pupate. It is by this formidable combine of a circle of enemies that the control of *Nephantis serinopa* appears to be brought about in nature, in spite of its fecundity. The huge groves of palmyra palms found throughout the plains of South India would appear to be the natural breeding grounds of the pest and act as nature's reservoir from which parasites are drawn by her when an outbreak occurs on coconuts. It will perhaps, therefore, depend ultimately on the presence or absence of palmyras in the particular area, whether or no the parasites are going to establish themselves permanently when newly introduced in any place.

The account given in this paper is only of the nature of preliminary notes of investigations and experiments that are yet in progress and the conclusions arrived at are, therefore, confessedly tentative.

THE PARASITES OF THE PEST IN COCHIN.

Since the above note was written, the writer had opportunities of examining a severe infestation of this pest in the State of Cochin ; the outbreak having occurred in that continuous belt of coconut groves extending along the backwaters from Cranganore southwards into Travancore. A concensus of opinion among the people connects the outbreak with the abnormal rainfall and floods of the monsoon of 1924. It is probable that the pest was conveyed from the endemic areas of the pest in Travancore through the agency of boat traffic. By May-June 1925, the trees were at their worst, most of the fronds looking as if they had been scorched. Prompt measures were taken by the Superintendent of Agriculture, Cochin State, in having the infested leaves cut and burnt by bringing in the aid of the Pest Act. One round of cutting was finished throughout the area in the course of 3 months.

At the time of the visit paid by the writer in November, the infested trees were found to present a fairly healthy appearance and there did not appear to be much of re-infestation. On a close examination of the various attacked areas, it was apparent that this happy result was really due to the activities of certain indigenous parasites,

and it was found unnecessary to take any special steps for the introduction of parasites from other places.

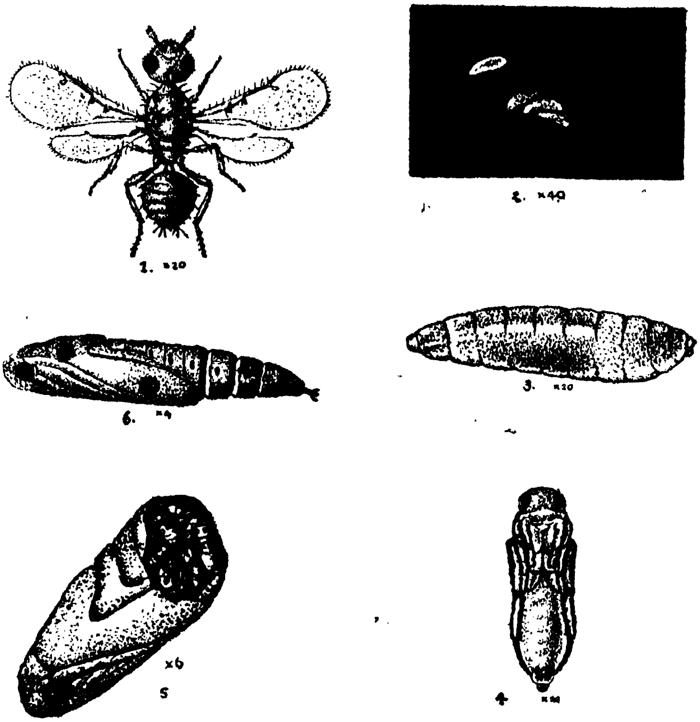
The parasite complex in Cochin was, however, somewhat different from that found in places on the East Coast, and appeared to be more like that reported by Dr. Hutson on the West Coast of Ceylon.

1. *The large pupal parasite—Stomatoceras* was present and was similarly attacked by the Eurytomid hyper-parasite.

2. *Elasmus nephantidis* was present in great numbers and appeared to be functioning as an efficient parasite, but was hyper-parasitized by the blue Chalcid.

3. *The Bethylid* was also noted, but only in small numbers, as it was heavily hyper-parasitized by the small dark Chalcid.

4. *Apanteles*—the Braconid of the East Coast—was conspicuous by its absence, but there was in its place another Braconid—*Microbracon* sp.—which laid eggs on



Eulophid parasite.

1, Adult (×20); 2, Eggs (×40); 3, Grub (×20); 4, Pupa (×20); 5, *Nephantis* pupa, section showing the Eulophid pupae inside (×6); Empty *Nephantis* pupa parasitized by the Eulophid showing the holes of exit (×4).

the full grown caterpillar after paralysing it. Its grubs pupated in small silken cocoons inside the galleries. This also was hyper-parasitized.

5. *A Tachinid* fly was also found attacking the pest. The puparium of the fly was found inside the pupa. It was, however, noted only in small numbers.

6. *The Eulophid.* This is a small Chalcid wasp of yellow brown colour. The wings are remarkable in having two short erect tufts of dark brown hairs. This wasp oviposits numerous eggs inside pupæ, and the grubs that hatch imbibe the juices of the pupæ and grow. Ultimately the pupa becomes merely an empty shell filled by masses of grubs, which later on pupate therein and emerge in about 9 days. In Cochin this parasite was found to be the most efficient of all and wherever it predominated the pest was not at all noticeable.

Dr. Hutson also mentions about the efficiency of this parasite in Ceylon. This parasite was also noted at Mangalore in 1925, but only in small numbers.

Attempts have been made to introduce this parasite in numbers into Mangalore and also around Coimbatore and results are being watched.

SELECTED ARTICLES

A HYBRID BETWEEN ASIATIC AND AMERICAN COTTON PLANTS *GOSSYPIUM HERBACEUM L.* AND *GOSSYPIUM HIRSUTUM L.**

BY

G. S. ZAITZEV.

[*Translated by A. E. Vossnessenski and Edited by Trevor Trought.*]

[In " The Agricultural Journal of India," Vol. XX, Part III, a summary of the following paper was published. The full translation which is now available, thanks to the kind assistance of Mr. A. E. Vossnessenski, doubtless will be of interest to all cotton botanists. Every effort has been made to give an absolutely literal translation of the Russian text even at the expense of clearness in English.—B. C. Burt.]

The opinion that the cotton plants of the New World cannot be successfully crossed with those of the Old, was established as the result of Trevor Clark's investigations (in the seventies of the 19th century), and it has remained up to the present time as a generally accepted one. The single exception to this general attitude is the opinion of Sir George Watt, who, on the ground of the existence of some similar characters in these physiologically separated groups of cotton plants, insists on the possibility of crossing between Asiatic and American plants. All attempts at crossing, however, up to now have invariably proved failures with the single exception of the experiments of Prof. Gammie, who worked in India and who, in his experiments in 1901-1903, was successful in obtaining a hybrid between *Gossypium roseum* Gammie (Varadi) and *Gossypium hirsutum* L. (Dharwar).

This hybrid, according to Gammie, was an exact copy of the variety *Bani* (Central Provinces), which Watt considers as a special variety of *G. Nanking* Meyen var. *Bani* Watt. (As regards *G. roseum* Gammie, it is, according to the classification of Watt, *G. arboreum* L. var. *rosea* Watt.) As we have not got at hand the original report of Gammie, we do not know anything about the subsequent fate of the hybrid. The difficulties, which crossing between the above mentioned groups presents, are easily accounted for by the fact that these groups are so remote geneti-

* Reprinted from *Trans. Turkestan Plant Breeding Station, Tashkent.*

cally. It is of interest to point out here that the investigation of M-me A. G. Nicolaeva, based on our material, disclosed a wide difference in the number of chromosomes in American and Asiatic species. Thus the somatic cells of *G. herbaceum* L., *G. Nanking* Meyen, *G. obtusifolium* Roxb. contained each of them 26 chromosomes, which number thus we can consider as characteristic for the Asiatic group of cotton plants. At the same time the somatic cells of *G. barbadense* L., *G. hirsutum* L., *G. mexicanum* Tod. and *G. punctatum* Tod., contained 52 chromosomes.

Some observations on the morphology of the flowers of cotton plants led to the supposition that there are also several mechanical obstacles in the way of successful crossing between Asiatic and American forms. The results of these can be summed up shortly as follows :—

(1) The alien pollen tube (from another species or variety) grows more slowly in the tissue of a strange flower than in its own, and the more genetically distant the forms are, the more the growth will be retarded.

(2) Under natural conditions the cotton flower is receptive to pollen during one day only, for on the next day, owing to the continued growth of the ovary and the stopping of growth of the corolla, the style is ruptured by the corolla sliding down and falls off together with this latter. The prevention of the premature rupture of the style by removing the whole corolla together with the stamen-tube makes the flower receptive to pollination also on the second day.

The preliminary experiments in crossing between American and Asiatic cotton plants, which were carried out with the application of the new method of emasculation of the flower, consisting in the removal of the corolla (thus preventing the premature rupture of the style), although they did not give entirely satisfactory results, nevertheless clearly demonstrated the formation of the hybrid embryo, thus giving confidence that under definite conditions and with a sufficient range of experiments it would be possible to succeed in obtaining proper hybrid normal seeds.

It was in this spirit of confidence that the crossing experiments were carried on in the year 1921 at the Turkestan Plant Breeding Station on a much larger scale as compared with the experiments of 1920. As it was intended to sort out tentatively the most promising species with regard to the possibility of favourable results crossings were made in various directions. The American forms were represented by several varieties of *G. punctatum*, *G. hirsutum*, *G. mexicanum* and *G. barbadense*, in all 19 in number ; the Asiatic forms by the varieties of *G. herbaceum*, *G. Nanking* and *G. obtusifolium*, 16 in all.

In all the crossing experiments which numbered about 300 (from 8/VIII to 15/VIII), the Asiatic forms were invariably taken for the female parents. On the eve of the day of pollination with the alien pollen, the buds were emasculated and isolated under parchment caps. The whole corolla was removed and the pistil

was completely exposed ; thus of course the possibility of rupturing the style was entirely prevented. In order to obtain quite pure pollen, flowers were also protected on the evening before the day of the crossing.

In several cases the repeated application of pollen was resorted to ; this procedure was applied in 133 cases. This repeated pollination, however, had no apparent effect, as it did not result in any deviation from the generally observed process of development of bolls.

Moreover, the repeated pollination (on the following day) of the flower of the said cotton plant, with the pollen, which was taken, not from American but from the female parent plant, also did not produce any changes in the process of the fructification. This circumstance leads to the conjecture that either at the time of application of the second portion of pollen tubes, the micropyle was already filled with the first portion, or that all the ovules were already fertilized. The second conjecture appears to be more likely, although the question may be finally solved only by means of detailed cytological investigation.

In the vast majority of cases during the experiments in 1921 the development of the ovary up to the size of an almost grown up boll was observed ; the further process of development was, however, stayed and the bolls prematurely opened and dried up. All investigations showed the forming of the hybrid embryo but it was never fully developed, just in the same way as was indicated by the experiments in 1920. Without entering here into the details, which did not bring out anything new, as compared with the results obtained in 1920, it may be pointed out that as the result of the crossings carried out in 1921 not a single normally developed boll was obtained. However, several bolls, although under-developed, contained one or more normally developed seeds. These seeds differed from the others contained in the same boll, by the normal strength (ripeness) of their fibre and by the normal dark colouring of the skin.

Six such bolls were obtained in all, and the total number of normal seeds contained in them was 14.

Some of them—8 (as it was subsequently found)—represented the result of accidental self-pollination, and others perished owing to various external causes, without having developed sufficiently mature plants. In the final result a single plant, F_1 51, was preserved, which had been obtained from a single fully developed seed, contained in the boll obtained as a result of the crossing No. 277, between ♀454 *G. herbaceum* and ♂221 *G. hirsutum* var. *lacinata* (var. nova). On the tenth day after it was transplanted into the ground it showed a perceptible reddening of the pulvinus of the cotyledons, and this reddening spread downwards from the pulvinus along the stalk. This exhibition of anthocyan colouring at this spot (which is entirely devoid of colouring in the case of ♂454, *i.e., G. herbaceum*), quite definitely indicates the influence of *G. hirsutum* (♀ No. 221). We give here a comparative description of the hybrid as well as of parent plants of the same age, made on 23rd May (14 days after germination).

Description.

Part of the plant	♀ 454 *G. herbaceum*	F_1 51—♀ 454 × ♂ 221	♂ 221 *G. hirsutum* var. *lacinata*
Hypocotyl .	Lower part coloured with anthocyan ; short hairs.	Lower part coloured with anthocyan, as in the case of ♀ 454. Long rarely spaced hairs.	Lower part brightly coloured with anthocyan ; convex glands ; no hairs.
Cotyledons	Smooth ; stalks covered with short hairs ; anthocyan colouring entirely absent.	Smooth ; stalks covered with very long hairs ; slight anthocyan colouring is displayed along the edges. The colouring becomes more intense in the upper part and in the pulvinus ; veins are also coloured. On the whole, however, the colouring is slighter than in the case of ♂ 221.	Smooth ; stalk without hairs ; bright anthocyan colouring particularly along the edges. Bright anthocyan colouring in the pulvinus, spreading on to the veins as well.
First internode .	Short dense hairs with rare long ones.	Long rare hairs . .	Glabrous with convex glands (much more so than in case of ♀ 454 and F_1 51 glands).
First leaf . .	Simple : covered with comparatively long hairs along the edge and veins (as well as between those, sometimes).	Simple : covered with comparatively long hairs on the edge and along the veins (on the upper and lower sides). In the pulvinus a spot of anthocyan colouring can be seen.	Simple : rare long hairs along the edge ; bright anthocyan spot at the pulvinus and on the upper part of the stalk.
Second leaf .	Not developed entirely, but obviously 3-parted.	Not developed entirely, but clearly 3-parted.	Simple.

Below we give a full comparative description of the hybrid as well as of the parent forms, according to different characters. The first part consists of the description recorded on 30th May, when all the plants had already developed three true leaves. In order to avoid repetition, the subsequent changes in the items described are recorded here ; the second part gives particulars of the further development of the hybrid compared with that of the parent forms, and the third the description of the particulars of the flowers.

I. Indument.

♀ **454**. Two layers. The lower layer of very short, densely spaced hairs covers all parts of the plant, with the exception of the cotyledons, which are entirely glabrous

A second layer of longer and more sparsely distributed hairs is perceptibly exhibited on the second internode of the stem and above, also on the leaves, especially on the lower side and along the petioles.

♂ 221. Only long hairs are present sparsely distributed on the internodes, leaves and stalks. The hypocotyl as well as the cotyledons are entirely naked.

F_1 51. Only long hairs are present sparsely distributed on all parts of the plant with the exception of the cotyledons.

On the whole, with regard to the development of hair cover, it can be said that, at this stage of growth, the hybrid occupies, to a certain extent, an intermediate position between the parent forms, in such a way that this character is more strongly exhibited when compared with ♂ 221 and suppressed when compared with ♀ 454.

With further development of the plant the hair cover of the hybrid was considerably intensified; the length of the hairs reached 2·55 mm., while ♂221 had hairs 1·5 mm. long and ♀ 454 2 mm. long. This latter had besides a very dense layer of short (less than 0·5 mm.) hairs.

Thus the hybrid subsequently, when adult, lost its intermediate position (with regard to the development of hair cover). The length of the hairs as well as the density of the hair cover was greater in the case of the hybrid than in the case of either of the parent forms.

Unlike ♀ 454 the hybrid has never exhibited the second layer of shorter hairs.

The resinous glands.

With regard to this character no difference was observed between hybrid and parent plants.

Also no difference in this respect was ever found subsequently in the adult plants.

The shape of the leaves.

♀ 454. The first leaf is not lobed and its width is greater than the length. The second leaf has three lobes and its width is also greater than the length. The third leaf has three lobes.

♂ 221. The first leaf is not lobed; its length is greater than the breadth. The second leaf is slightly lobed (2 parts).

F_1 51. The first leaf is not lobed and, with regard to the ratio of the length to the breadth, it occupies a somewhat intermediate position between the parent forms.

The second and third leaves have three lobes and their length and breadth are nearly equal. Thus, with regard to the shape of the leaf, the hybrid clearly occupies an intermediate position. This position, with regard to the comparative size of the parts, was maintained during the further development. The leaf factor (accord-

ing to Leake) (as measured on the 15th July) had for the fourth, fifth and sixth leaves the following values : ♀ 454—0·90, ♂ 221—1·42 and F_1 51—1·09 (the mean value for the parent forms is equal to 1·16).

Measurements taken subsequently on the tenth leaf resulted in the following values of the leaf factor : ♀ 454—1·08, ♂ 221—3·54 and F_1 51—2·00 (the mean value for the parent forms is equal to 2·32). With further growth, the lobing of the leaves was (as usual) more strongly exhibited, but its relative expression was on the whole preserved.

The length of the middle lobe in the case of the hybrid was more intensely exhibited, as compared with the female parent, but less intensely as compared with the male parent.

With regard to the number of lobes, the intermediate position of the hybrid also was apparent to a certain extent, and this was maintained in the grown up plants as well.

If we denote the shape of the leaves (such as simple, 3-, 4-, 5-, or 7-lobed) respectively by the symbols O, A, B, C (using two letters to denote intermediate, one-sided forms) and introduce additional indices (dentata) to denote the development of teeth along the edges (which is characteristic in case of the more differentiated leaves of var. *lacinata*), then we can represent the comparative description of sixteen axial leaves by means of the following table :—

Leaf / Plant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
♀454 .	0	A	A	B	B	B	CA	C	C	C	C	C	C	C	C	C
♂221 .	0	0A	0A	0A	A	A	A	B	Bd	Bd	Bd	Bd	Bd	Bd	Bd	Bd
F_1 51 .	0	A	A	A	B	B	B	B	C	BC	BCd	C	Bc	Cd	Cd	C

It may be seen from this table that lobing of the leaves is more intensely exhibited in the case of ♀ 454 ; the differentiation of leaves also being earlier in this case.

In the case of ♂ 221 the leaves are fewer lobed, the increase of the number of lobes begins later and the 7-lobed leaf does not appear at all although the lobes (unlike in case of ♀ 454) often become dentated. As compared with both these forms (♀ 454, ♂ 221) the hybrid appears to have an intermediate shape of leaf with regard to the number of lobes as well as with regard to the development of teeth.

Stipules.

♀ ***454***. Stipules are rather large, lanceolated (with short hairs especially on the edges).

♂ *221*. Stipules are small, lanceolated with long rarely spaced hairs especially along the upper edge.

F_1 *51*. Stipules are large, lanceolated with rare longish hairs. It should be noted on the whole that the stipules of F_1 are more like those of the female parent ; as regards the development of hair cover, however, the influence of the male parent is more apparent, and with further growth of the plant, the hair cover of the stipules became more intense, along with the general intensification of the hair cover of the whole plant.

Anthocyan colouring.

♀ *454*. The anthocyan colouring was exhibited only in the lower part of the hypocotyl ; the other parts of the young plant were without colouring.

♂ *221*. The anthocyan colouring appears very clearly on the hypocotyl on the upper sides of the stalks of cotyledons and leaves, also as a bright spot in the pulvinus.

F_1 *51*. The anthocyan colouring is exhibited in the same spots as in case of ♂ 221, but is considerably slighter.

With regard to the development of anthocyan colouring, the hybrid plant widely differs from the maternal form. This difference is preserved in the case of adult plants as well, although with age ♀ 454 also exhibits perceptible anthocyan colouring on the illuminated side of the stem, and sometimes in a very slight degree on the upper part of the petioles.

In the case of the male parent and hybrid the intensification of the anthocyan colouring occurs in a much larger degree, and in this respect the hybrid shows a predomination of the form *G. hirsutum*.

Nectaries (glands Ed.) on the leaves.

♀ *454*. There is one nectary on each leaf ; they are without hairs (?) ; their shape is round.

♂ *221*. Nectaries on the leaves have an elongated shape ; they have no hairs inside.

F_1 *51*. Nectaries on the leaves have an elongated shape ; they have no hairs inside.

With regard to the shape of the nectaries the hybrid approaches ♂ 221 ; with further development, the number of the nectaries increases (up to 3), but no essential difference in their structure was noted.

II. FURTHER DEVELOPMENT OF HYBRID.

With regard to the further development of the hybrid it is to be noted that it grew much faster than either of the parent forms, and at the time of the beginning of flowering considerably exceeded them both as regards height.

This exceptional growth was particularly apparent in the autumn, as the hybrid reached the height of 2·74 mt., while the height of ♀ 454 was 1·47 mt. and that of ♂ 221 1·40 mt.

Development of branches.

With regard to the development of branches the hybrid presented the picture common to all the cotton plants, which was faithfully repeated in the case of both parent plants.

It developed in the lower part several monopodial (vegetative) branches, coming out of the primary buds. In the beginning these branches were accompanied by monopodial branches developed from additional (secondary) buds and higher at the very top the sympodial branches developed from the additional (secondary) buds.

All branches originated from secondary buds were naturally less developed.

Size of sympodial branches.

In the case of both the parent plants the sympodial branches had rather long internodes, but in the case of the hybrid these were still longer; the number of internodes (and consequently the number of flowers) was also greater than in the case of parent forms.

Flowering.

The first sympodial branch was developed at the sixth leaf of the principal stem, which circumstance determined an early period of flowering.

The hybrid developed flowers simultaneously with the parent forms and the general process of flowering was quite in accordance with the rules established for the cotton plants by the author elsewhere (*see* "Flowering," "Fructification", etc.) The relation of the long succession of flowering to the short succession was found to be equal to 2·5, so that the hybrid according to its process of flowering may be considered as an early ripening form.

The intensive growth of the hybrid found its expression among others in the corresponding intensive development of sympodial branches of which the lowest bore 14 flowers. During the whole period of its flowering the hybrid gave a total number of flowers exceeding 500. Along with primary flowers, secondary ones were developed from additional branches, so that on the whole the luxurious growth of the hybrid was by no means detrimental to the development of flowers, but on the contrary forwarded and helped it.

III. Particulars of the flower.

Peduncle.

♀ *454*. Densely covered with short hairs; as well as with rarely spaced longer ones.

♂ 221. Only long rarely spaced hairs are present (in the immediate vicinity of the flower the hairs are somewhat more densely spaced).

F_1 51. Long comparatively densely spaced hairs.

Bracts.

♀ 454. The bracts are closely united at their base (up to ⅓ of the height). The denticles (teeth) are small and not numerous (8—10)[1].

♂ 221. The bracts are loose. The denticles (teeth) are large and numerous (12—14).[2]

F_1 51. Most of the flowers have loose bracts; some flowers have, however, united bracts, although in a slighter degree than in the case of the female parent. The denticles (teeth) are of medium size, their number is the same as in the case of ♂ 221.[3]

Calyx.

♀ 454. The calyx is undulate (5 waves), glabrous on the outside, with solitary hairs along the edge.

♂ 221. The calyx is 5-toothed, glabrous on the outside with some hairs on the edge, particularly at the tips of the teeth.

F_1 51. The calyx is five-toothed, glabrous on the outside.

Nectaries outside the flower.

(*a*) Outer (on the stalk). ♀ *454*—absent; ♂ *221*—present in most cases; they are oval-shaped and roundish; with rare hairs inside; F_1 *51*—absent or sometimes very slightly developed.

(*b*) Inner (under the calyx). ♀ *454*—large, triangular with densely spaced short hairs; ♂ *221*—not perceptible; F_1 *51*—round or triangular, smaller than in case of ♀ 454, with longer and somewhat less densely spaced hairs.

Nectaries inside the flower forming a ring on the inner side of the base of the calyx.

♀ 454. Without hairs.

♂ 221. With a ring of hairs pressed upwards.

F_1 51. In the same way as in the case of ♂ 221, but the hairs are shorter and more rarely spaced.

[1] The outer side and the edge are covered with comparatively short hairs.

[2] The hair covers in the same way as in the case of ♀ 454; also along the veins. The hairs however are longer and more rarely spaced.

[3] The hairs are more densely spaced than in the case of ♂ 221. The length is intermediate between those in case of parent forms.

Petals.

♀ ***454.*** Most of the flowers have irregular petals of bright yellow colour with a dark crimson spot at the inner side of the base ; a smaller spot also appears at the outer side.

♂ ***221.*** The petals are of regular shape ; the colour is light yellow (cream). No spot.

F_1 ***51.*** The shape is regular, colouring intermediate ; the majority of the flowers are without spots. Only the flowers of the first sympodial branch and of two secondary sympodial branches have the petals with a spot, although much slighter than in case of ♀ 454. Thus this character (spot) once being exhibited is retained throughout all the flowers of the branch.

Anthers (and pollen).

♀ ***454.*** Yellow.
♂ ***221.*** Light.
F_1 ***51.*** Yellow but lighter than in the case of ♀ 454.

Staminal filaments.

♀ ***454.*** Red on the lower filaments.
♂ ***221*** *and* F_1 ***51.*** Light.

IV. Particulars of the fruit.

♀ ***454.*** The boll is 4—5 locular, rather broader than long, slightly dehiscent ; the seed has white fibre and light green (greyish) down.

♂ ***221.*** The boll is 4—5 locular, egg-shaped, well dehiscent. The seed has white fibre and light green (greyish) down.

Hybrid. The ovary is 4—5 locular.

As stated above, the process of the flowering of hybrid progressed quite normally ; its very first flowers, however, very soon showed complete sterility. Pollination, natural as well as artificial, inevitably resulted in the falling off of the young ovaries.

Microscopic investigation disclosed the deformation of the pollen of hybrid.

Pollen of the usual spherical shape was very seldom observed ; mostly it had a distorted semi-spherical shape. It did not swell up and burst subsequently under the action of moisture as is usually observed with the normal pollen of a cotton plant. The swelling up and bursting was observed only in a few solitary cases. Owing to this it was decided to try the pollination of the flowers of the hybrid with the normal pollen of other forms. Accordingly the pollen of both the parent plants was tested as well as of many other forms (*G. barbadense*, *G. hirsutum*, *G. herbaceum*

G. Nanking, etc.). The results were invariably negative, and fructification did not take place. The pollination of the parent and other forms with the pollen of hybrid did not lead to any results either. This fact proved that notwithstanding the apparent normality of the development of hybrid, one of its physiological functions was entirely suppressed. Till the very end of the vegetative period, in spite of the large number of flowers the hybrid remained sterile and all the ovaries invariably fell off. In order to continue during the next year the observations on the hybrid this latter was preserved alive till the next season, 1923.

AGRICULTURAL AND MECHANICAL ENGINEERING IN INDIA.*

BY

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IN a thoughtful article contributed to the "Asiatic Review" in July 1925 on agricultural and mechanical engineering in India, Sir Alfred Chatterton gave it as his opinion that the development of agriculture in India is likely to be of a very restricted character unless it connotes the application of the resources of mechanical engineering to the tilling of the soil, the supply of irrigation water, the harvesting of the crops, their transport to factories, and to the machinery for converting them into finished, or at any rate easily marketable products. If the people of India are, he says, to achieve any marked degree of industrial success in the future they must cease to neglect mechanical engineering and must realize that in its application to agriculture there lies a field open to immediate exploitation. The initiation of measures must, however, rest with the principal landowner, namely, the Government; the cultivators, numerous and poor, have no natural leaders and by temperament are conservative and suspicious.

To achieve results commensurate with the interests involved, he advocates standardization of plant as being absolutely essential. What Henry Ford has shown to the world can be done with such a complex machine as a modern motor car required for service under an almost infinite variety of conditions can, he avers, be achieved in India with ploughs, motor pumps, sugar mills, threshing machinery, oil presses, and a number of hand tools of almost universal utility : India pays dearly for the privilege of being able to select its machinery from the numerous competitive types imported from abroad. Notwithstanding the decentralization of the control of the Departments of Industries and Agriculture, the Government of India are still in a position to standardize the requirements of rural India, and if suitable standardized iron ploughs, for example, could be substituted for the thirty millions or so inefficient wooden ones at present in use, nearly half the draught cattle could, he thinks, be dispensed with, or the work of ploughing done in half the time.

To the development of agricultural engineering even in the more advanced countries the services of mechanical science have not been applied to anything

* **Reprinted from *The Pioneer* Trade, Industrial and Economic Supplement, November 1925.**

like the same extent as to that of the great manufacturing industries of the world. Mechanical discoveries in other fields of engineering have, however, tended to filter down to agriculture and to be gradually adapted to its requirements. In these countries farmers have been forced by economic conditions to resort to the use of labour saving machinery; for manual labour on the farm means dear labour and high production costs. The cultivation of the soil has been raised to a fine art, and a great variety of highly specialized implements designed for the various operations such as ploughing, sowing and harvesting are freely used.

In India we are now at the transition stage between manual and mechanical power on the farm. A beginning has been made in substituting steam and internal combustion engines and in introducing implements and machines worked by bullocks. The relatively low standard of cultivation attained in India is largely the result of the inefficiency of the local plough; this same plough, inefficient though it is, is used for several operations for which special implements have been invented in the West. This plough may be roughly described as a piece of wood shod with an iron point which corresponds to a share. It is fitted with a wooden pole and is drawn by one or two pairs of bullocks. It has no mould board and having no cutting parts it does not eradicate weeds. The iron ploughs now being introduced are the handiwork of engineers who have devoted much time and thought to their evolution. The exact relationship of their different parts to the work which they have to do has been thoroughly studied with the result that we have to-day various types of ploughs which are well nigh perfect.

Within the last 20 years several attempts have been made to design types of a plough suitable for India. For these attempts, several of which have been successful, we are mainly indebted to one or two well-known English engineering firms, but particularly to Ransomes, Sims and Jefferies, assisted by agricultural experts in this country. The ploughs evolved may be described under three heads, namely, heavy ploughs, medium ploughs and light ploughs. Heavy types such as the Steel Eagle and Turnwrest are suitable for heavy soils such as the black cotton soil found over a great part of Peninsular India; of these there are many thousands now in use, more especially in Bombay and the Central Provinces. Being heavy in draught they require from 2 to 3 pairs of good bullocks. Of the lighter types introduced the M. S. N. is the best known. Many of these are now at work in the rice tracts of India. Two or three excellent ploughs of medium weight have been designed for use in the Gangetic alluvium of Northern India, where they are used both in the cold weather and during breaks in the rains. One of the best ploughs yet designed for India is the Sabul, the characteristics of which are that the share is provided with an adjustable bar point of high grade steel. The bar is held in position by a steel wedge knocked in from the front. The Sabul is suitable both for stiff black cotton soil and for the lighter soils of the Gangetic plain.

It may be pointed out here that the designs of ploughs invented by enterprising English engineer firms are now being copied in India, and that considerable numbers

of somewhat roughly-made but useful imitations of the English article are being manufactured and sold in this country.

The chief handicaps in the way of introducing improved iron ploughs on a large scale are that the bullocks which supply the motive power are, over a great part of India, somewhat weak and small ; still an ever-increasing demand for such ploughs has already been created. The demand is the result of the activities of Departments of Agriculture ; for provincial departments have demonstrated their use in the villages and have on Government farms stocked for sale and hire the types found suitable. From these Government depôts 20,227 ploughs and 9,249 spare parts were supplied last year. The existence of a demand for spare parts would appear to indicate that the ploughs are being freely used.

There are millions of acres of weedy land in India which year after year give poor yields because the land is infested with *kans* or other persistent weeds which rob the crop of much of its plant food and moisture. There are, moreover, hundreds of thousands of acres of good land lying fallow because these weeds have entirely overrun the fields. Very large stretches of such land are to be found more especially in the Central Provinces, Bundelkhand and in Gwalior. In many cases these lands were overgrown with *kans* after the great famines of 1896-97 and 1900-01 as a result of the bullock power available being reduced to a very large extent, owing to shortage of fodder in these years. This weed can be eradicated by means of iron ploughs worked by strong pairs of bullocks or buffaloes ; but the number of these available is limited. For such tracts there is little doubt but that there is an opening for the use of steam ploughs and perhaps motor tractors.

Steam ploughs have been in use in the West for over 70 years. At the present time there are about 40 sets of Fowler's steam tackle worked on the cable system in India. That many more have not been used is due to the fact that the bigger land owners who might reasonably be expected to use them have not yet come forward to play their parts as pioneers in the field of agricultural development. In the cable system of steam ploughing the engines remain stationary while pulling the plough or other implement used, and can therefore develop their full draught power on the cable. This gives an enormous saving in efficiency as compared with a motor tractor which loses much of its power in pulling itself. The chief advantages claimed for steam cultivation by the cable system are that any depth of ploughing up to 30 inches can be done by this system ; that land overrun with persistent weeds can be reclaimed with ease, and that the work is done very quickly. With a K type double engine cable set an area of almost an acre can be ploughed to a depth of 11 to 12 inches in an hour.

During the last five years motor tractors have been tried in different parts of India. The general opinion now is that they are useful for two purposes, namely, for (1) light and shallow cultivation on large estates when a considerable area of land has to be cultivated in the shortest possible time, and (2) for clearing lands in-

fested with persistent weeds. They are being used, too, for stationary work, but when employed for such work are less economical than an oil engine. The types of tractors tested in India up to date are not sufficiently powerful for ploughing where the soil is very heavy and weedy. They are not sufficiently fool-proof either; it is very difficult to keep them in good running order, as first class mechanics are not easily obtainable and spare parts are not always available in this country. Still the fact remains that with intelligent use the tractor is a farm-power unit of considerable possibilities in tracts where the draught power at present available is inadequate, and where, in the absence of any other form of mechanical power, it is impossible for the agriculturist to perform his tillage operations under optimum conditions. The introduction of iron ploughs on a large scale in India supplemented by the use of mechanical power in the shape of steam and internal combustion engines would enable the cultivator to get his land ploughed more quickly and therefore under more favourable conditions. It would enable him, too, to get rid of the weeds which at present rob his crops of their rightful dues, and to bring under cultivation large areas of good land which has been overrun with *kans* or other weeds.

There is already a large demand in India for iron cane mills and some demand for power pumps, winnowers, reaping machines, fodder cutters, threshers, hoes, and harrows. There is a growing demand, too, for pig-proof fencing, for both wild and domesticated animals do an enormous amount of damage every year to crops. Of the wild animals the pig is, perhaps, the most destructive and the most difficult to control. Being a nocturnal feeder he lies hidden during the day in the jungle or grass covered waste land, and comes out at night to feed on the village crops. Pig-proof woven fencing is being introduced in some provinces with excellent results; the demand for such fencing is likely to increase very much.

When the landed aristocracy of India waken up to a sense of their responsibilities the demand for improved hand and power appliances for the better cultivation of the land will be enormous: the annual demand for ploughs alone may run into hundreds of thousands. To foster and stimulate the demand the Department of Agriculture is doing its utmost. It is demonstrating the working of approved implements and machines in the villages. It displays them at agricultural shows and ploughing matches. It stocks them for sale and in some cases for hire at depôts on Government farms. It is organizing their sale through co-operative societies, and in some provinces it is giving pecuniary assistance in the shape of *taccavi* for their purchase. More than this it cannot do at present; for its staff is small and its activities extend over a very wide field of which the introduction of labour-saving machinery forms but a small part.

ERRORS IN FEEDING LIVE STOCK.*

BY

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During the past 25 years, hundreds, if not thousands, of papers have been published, many of them containing facts and observations each of which has added a little to the sum of our knowledge of the laws of nutrition of farm animals. It would, I suppose, be within the bounds of possibility to give a detailed catalogue of these individual papers, setting out the salient points of each. Such a proceeding would take a very considerable time, and would be quite useless to the farmer, although valuable to the investigator. Indeed, every investigator before he starts his investigation makes such a catalogue in his special line of work, either on paper or in his own mind, in order that he may experiment in the light of other people's results.

I myself have read many of the papers on nutrition published during the last 25 years, and what I propose to set out is the general impression of the practical value of nutrition research which their perusal has left on my mind. It will of necessity be a personal impression—another writer might stress different points—but I hope it will be useful to the practical man, as it has been to me, not only in the conduct of my own research work but in the rationing of the animals on my own farm.

TRADITIONAL METHODS ARE WRONG.

My first impression, and I do not think this particular point is open to argument, is that the great majority of owners of live stock who feed their animals on traditional lines, are wrong in the following particulars :—

(1) They include too much protein in the rations of their fattening animals.

(2) They include too much protein in the ration of their working animals.

(3) They do not give enough protein to their young growing animals.

(4) They do not give enough protein to their milking animals.

(5) They do not give enough ash constituents of the right kind to their growing animals and their milking animals.

Points 4 and 5 are, however, not within the province of this article. They have been dealt with already by Mr. Mackintosh, of Reading, Dr. Orr, of Aberdeen, and Dr.

*Reprinted from *The Farmer and Stockbreeder and Agri. Gazette*, No. 1889.

Crowther, of Harper Adams College; consequently, I do not propose to discuss them further. The remainder of this article will be devoted to discussing points 1, 2 and 3.

Protein for fattening animals.

The usual method of feeding fattening animals, namely, to give them roots and straw or hay, supplemented by a generous ration of oilseed cakes, has been handed down traditionally from the time when it was started at the close of the days of the great landlords 70 or 80 years ago. It originated from the work of the first chemists who turned their attention to agriculture, and concluded, on grounds which have subsequently been found to be wrong, that fat could only be produced in the animal body from fat or oil and protein. Oilseed cakes, being rich in both these constituents, seemed excellent for fattening, their use became general, and the custom has lasted.

It is about 70 years since Lawes and Gilbert showed that most of the fat formed in the body of a fattening animal was formed from carbohydrates, such as starch and sugar; but this observation, although accepted by physiologists, is only just beginning to find its way into agricultural practice as the result of more recent research.

Recent accurate research on this subject dates from Kellner's measurements of the fat-producing power of proteins, oils and carbohydrates, which showed that proteins were distinctly less effective fat-producers than either of the other recognized constituents of feeding stuffs. Still more recent work has shown that full-grown animals required much smaller amounts of protein than most rations provide, and that increased supplies of protein in the case of such animals do not raise the rate of live-weight increase.

The amount of digestible protein required by full-grown animals on full fattening rations is well known. It is, for a full-grown or approximately full-grown steer. not more than 1½ lb. of digestible protein per day; for a full-grown sheep not more than 1¾ lb. of digestible protein per week. These quantities are usually greatly exceeded. The excess does no harm to cattle, except, of course, that its provision entails wasteful expense. In the case of sheep, an excessive supply of protein is apt to cause death through failure of the kidneys.

Protein for working animals.

As with fattening stock, so with working animals, the traditional idea is that protein is the source of muscular energy. This is not true, and there is no need to increase the protein in the ration of an animal because it is required to do hard work. It is unfortunate, however, that no important additions to our knowledge of the protein requirements of the horse have been made in recent years.

PROTEIN FOR YOUNG ANIMALS.

It is desirable that a young animal should grow, and consequently that it should increase in weight. The food requirements of the growing animal are to a very large extent governed by this fact, since they must not only keep the animal alive but must provide the material of which the increased weight is composed. In recent years much work has been done on this subject, the gist of which is that the increase in live weight made by a young animal consists mainly of water, but contains considerable quantities of protein and ash. It is noteworthy that a young, rapidly growing animal usually puts on very little fat.

Protein being the most abundant constituent of the live weight increase of young animals (of course excepting water), it follows that a young animal requires a liberal supply of protein in its ration. Traditional practice does not give this, especially in the case of cattle. As a rule, young stock are wintered on poor pasture with perhaps a little poor hay or in yards on poor hay or even straw and a few roots. They would do very much better and so would their owner, if they got some of the cake which is so often wasted on fattening cattle and sheep. This fact is beginning to meet with some measure of recognition, especially in the production of "baby" beef fat lambs and pigs which are ready for the factory at six or seven months old.

COMPUTING RATIONS.

My next point is that the knowledge which has accumulated as the result of the research work carried out during the last 25 years makes it possible to compute a ration which will produce any desired result within the possibility of the animal which is to consume it.

For some time past, advanced milk producers have adopted the method of basing their rations on the principle of maintenance ration *plus* an additional allowance per gallon of milk. In much the same way it is possible to compute rations for young growing animals or for fattening animals on the basis of maintenance ration *plus* an addition for each pound of live weight increase which it is desired to produce.

The essential points of rationing on this system are :—(1) That an animal's appetite is limited—a full-grown steer, for instance, will not eat more than about 25 to 30 lb. of food per day, weight in the dry state. (2) That a large part of this food is required simply to keep the animal alive—this is the maintenance ration—and its amount, measured by modern experiments, is given in the books referred to above. To this maintenance ration must be added so much real nutritive value per lb. of increase expected.

The more increase one expects, the more real nutritive value it is necessary to get into the limit of the animal's appetite : which means using highly digestible foods such as cakes, corn, meals and roots for the productive part of the ration.

For young growing animals requiring much protein, a good proportion of cake is desirable. For adult fattening animals, corn, meal, and roots are cheaper and more suitable.

STARCH EQUIVALENT.

It is usual to measure the real nutritive value of feeding stuffs in terms of their starch equivalent as determined by the method of Kellner. The weight of starch equivalent required to produce 1 lb. of increase in animals of various classes has been found from the results of modern research on the composition of the carcases of animals. This method of computing rations is a distinct advance on the methods hitherto in use. When it gets absorbed into the general practice of farming it will correct the common errors in feeding noted above, and will add materially to economy in animal production.

NOTES.

MOUNTING RICE SPECIMENS FOR EXHIBITION.

At present agricultural and industrial exhibitions are becoming more and more popular in every province in India. Even in a small province like Assam four exhibitions were held in 1925 and three in the current year in different districts. Consequently, every year the Provincial Agricultural Departments have to send exhibits of staple agricultural crops to several places. It is with a view to making portable and attractive specimens that the writer has tried to give below his experience in mounting rice samples during the last three years.

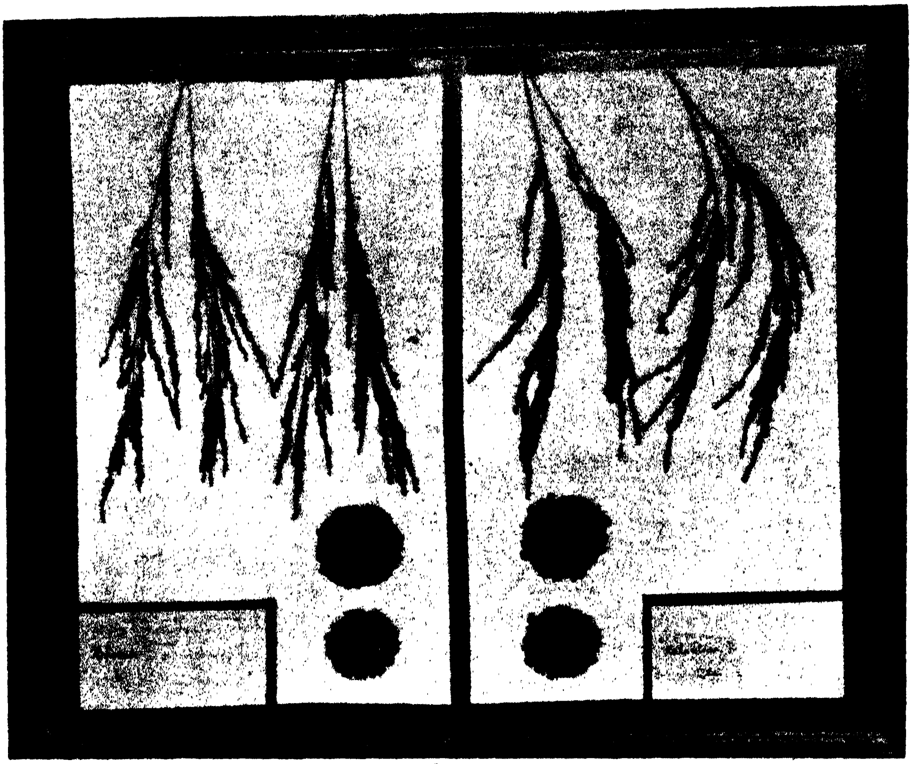
Ordinarily dried plant specimens are kept in herbarium sheets or card boards after being properly pressed and dried. They are either glued to the sheet or fastened to it with strips of gummed cloth or paper. Such exposed specimens, though serving the purpose of a museum, do not suit for display in agricultural exhibitions, where the common cultivators go and are naturally inclined to handle them. When it is desired to make permanent samples, such as that of rice, wheat, barley, etc., which, if kept exposed in the exhibition ground for days, are liable to be damaged, they can best be mounted in glass cases in an attractive way. Specimens of grain in ears, when mounted carefully, can be carried easily from place to place, as need be, and displayed year after year.

The method of mounting specimens such as the ears of rice, wheat and barley, is simple. They are to be mounted on cotton in a glass case having a moveable back which is fastened down tightly on the cotton. The specimen, thus mounted, remains imbedded in the cotton against the glass and can be easily examined through it.

In preparing wooden frames for glass cases, it is better to use teak wood which gives an attractive appearance. The frame may be made of any size that suits the specimen, but for the stalks of rice, wheat and barley it may preferably be about 21″ × 17″ × 1″ which will make room for the ears of grain very easily. Even ordinary picture frames can serve the purpose. The glass plate should be fitted inside as is done with picture frames. The back of the frame may preferably be made of venesta boards.

The specimen to be mounted should be placed in the mount upon the glass with face down and a layer of cotton batting should be placed on it so as to fill the space completely. The back should then be put on and fastened down tightly upon the cotton by brass cleats, thus holding the specimen securely in place against the glass front. Glass covered mounting cases may be made of cardboards, but for exhibition purposes they may preferably be made of wood.

In mounting specimens whole ears should be arranged on the glass plate side by side showing their full length from the point of insertion, and individual grains, both husked and unhusked, just below them. Thus two specimens can very well be put in side by side for comparison with labels at the corners below. Whenever



Two mounted specimens of rice fixed in a wooden frame with a glass front.

it is required to change a sample, the only thing to do is to unfasten the cleats and take out the venesta board and the cotton batting. After the new specimen is put in, they may be easily fastened again as before. In order to make the specimens more attractive strips of black paper may be placed on the glass on all sides. When two varieties are mounted together they may be separated by a similar strip of paper in the middle. In this way we have used three and sometimes four different specimens in the same glasscase.

It is very often found that insects and fungi attack the grains if they re not treated properly with chemicals. In our case good results have been obtained by treating the specimens with carbon bisulphide or 4 per cent. formalin solution. It is always better to spread some naphthalene powder on the cotton batting before the back is fastened down. Surgical absorbent cotton wool gives the best results as it comes out in thin layers. One layer can economically be used to face the specimen up on the glass. On this, several sheets of newspaper may be placed to fill up the space before the venesta board is fastened. One roll of absorbent cotton wool is good enough for three or four cases. [S. K. MITRA.]

REPORT ON THE INDIAN EGG-LAYING TEST, LUCKNOW, 1925-26.

THE number of birds tested was 57, and included the following breeds :—White Leghorns 31, Rhode Island Reds 6, Wyandottes 2, Australorps 8, Light Sussex 4, Buff Rocks 4, Black Leghorn 1, Ex. Leghorn 1.

The number of eggs laid by these 57 birds during the 92 days of the test amounted to 3,049 or an average of 53·5 per bird. This is a first class average and exceeds any previous record we have had.

The average number of eggs laid by each breed was as under :—

	Total number laid	Average per bird
31 White Leghorns	1,620	52·25
6 Rhode Island Reds	373	62·16
2 Wyandottes	130	65·00
8 Australorps	391	48·875
4 Light Sussex	253	63·25
4 Buff Rocks	200	50·00
1 Black Leghorn	29	29·00
1 Ex. Leghorn	53	53·00

The cost of feeding worked out at Rs. 2-3-10 per bird and of labour at As. 11-9 per bird, the total cost per head averaging nearly Rs. 3 a bird or R. 1 per month per bird.

The amount realized by sales of eggs came to Rs. 381-2 at the rate of R. 1-8 per dozen. Each bird, therefore, realized Rs. 6-11-0 on value of eggs sold or a net profit of Rs. 3-11 per head in three months.

The profit thus realized, together with entry fees, went towards the silver cups presented by the United Provinces Poultry Association to the winners.

The birds from overseas did not lay as well as in previous competitions, due to an unfortunate delay in the voyage from England. The ship that brought them broke down and the time of the voyage was nearly doubled. In spite of this long confinement, however, the birds kept well. They were sold after the test for prices averaging Rs. 30 or 2 guineas per bird.

The method of feeding has been described in former reports ; briefly stated it was as follows :—

7 a.m. Two oz. per bird of scratching grain, consisting of two parts wheat, one part cracked maize, buried in deep litter.

Midday. Green food *ad lib.*

4 p.m. Soft mash consisting of 2 parts bran, 4 parts wheat *ata*, 1 part maize meal, ½ part gram meal, ½ part fish meal ; the last item was increased gradually up to one whole part during the last month of the test. Epsom salt was given to each bird once weekly in the drinking water ; chopped onions were also added to the mash once in a week. Shell grit, charcoal and plentiful water supplies were constantly before the birds.

Eggs were collected and weighed at 4 p.m. each day. The eggs were scored on the principle of reckoning only 2 oz. eggs as scoring one point. Eggs under this weight were penalized and 20 per cent or one in every five eggs deducted from the total points when totalling the eggs laid. Most of the hens laid large eggs and every year sees an increase in the number of $2\frac{1}{4}$ oz. eggs laid by the competing birds.

We append a list of prize winners and the awards gained, with a photograph of the leading pullet. Captain Mayo, her owner, is to be congratulated, for this is the second year in succession that he has won the Governor's cup. It is proposed to admit 8 entries per competitor instead of 4 birds only at the next test commencing on 1st November, 1926.

LIST OF SPECIAL PRIZE WINNERS AT THE TEST.

Prizes	Winners
1. Governor's Cup for the best layer in the test, presented by H. E. the Governor of U. P. . .	Captain Mayo's White Leghorn pullet.
2. Cup for the best layer from India, presented by the Stewards of Lucknow Races	Captain Mayo's White Leghorn pullet.
3. Cup for the best layer from overseas, presented by the Stewards of Lucknow Races . . .	Mr. Bradbury's (England) Light Sussex pullet.
4. Cup for the best team of four hens, presented by the United Provinces Poultry Association . .	Mrs. Bomford's Rhode Island Red pullets.
5. Cup for the best heavy bird, presented by Messrs. Perry & Co.	Mrs. Bomford's Rhode Island Red pullet.
6. Cup for the best light bird, presented by the United Provinces Poultry Association . . .	Captain Mayo's White Leghorn pullet.
7. Cup for the best bird owned by a member of the Indian Poultry Club	Ditto.
8. Cup for the best bird owned by a resident of the United Provinces, presented by the United Provinces Poultry Association . . .	Mrs. Poychers's White Leghorn pullet.
9. Cup for the best bird owned by an Indian resident of the United Province, presented by the United Provinces Poultry Association . . .	Raja of Mursan's Rhode Island Red pullet.

Indian test winner owned by Capt. Mayo. This pullet laying 86 eggs in 92 days has equalled to any record put up at any of the world's tests for winter laying.

PERFORMANCES OF PULLETS ENTERED FOR THE TEST.

Owner	Breed	Pen No.	Total of eggs	Total to score	Awards
Mrs. Bomford, Sutna .	Rhode Island Red.	1	61	60·8	All got 1st class certificates and also won special prize No. 4 for best team. No. 4 also won prize No. 5.
		2	61	61·0	
		3	70	70·0	
		4	78	78·0	
Mr. Meakins, Dehra Dun .	White Leghorn.	5	39	38·8	
		6	27	27·6	
		7	46	45·4	
		8	67	67·0	1st class certificate.
Mr. Mackenzie, Ghoresahan.	Australorp .	9	43	39·2	
		10	72	60·4	Ditto.
		11	24	22·2	
		12	40	39·0	
Mrs. Savaille, Bhadrak .	Australorp . White Leghorn.	13	22	20·2	
		14	28	27·8	
Mr. Heathcote, Sylhet .	Light Sussex	15	54	46·8	
		16	67	54·0	Ditto.

PERFORMANCES OF PULLETS ENTERED FOR THE TEST—*contd.*

Owner	Breed	Pen No.	Total of eggs	Total to score	Awards
Mrs. Peychers, Dehra Dun	White Leghorn.	17	60	59·8	1st class certificate.
		18	70	68·8	Ditto. Also won special prize No. 8.
		19	51	50·8	1st class certificate.
		20	52	44·4	
Captain Mayo, Nahan	White Leghorn.	21	58	50·0	Ditto.
		22	29	26·8	
		23	59	58·0	Ditto.
		24	86	83·3	Ditto. Also won special prizes Nos. 1, 2, 6 & 7.
Mrs. Thomas, Meerut	White Leghorn.	25	39	35·8	
		26	60	59·2	1st class certificate.
Raja of Mursan	Rhode Island Red.	27	40	39·6	
		28	63	60·8	Ditto. Also won special prize No. 9.
	Australorps	29	62	59·8	1st class certificate.
		30	61	56·0	Ditto.
Mrs. McWaters	White Leghorn.	31	62	57·4	Ditto.
		32	38	27·2	
Mr. Turkman, Lucknow	White Leghorn.	35	51	50·4	Ditto.
Mr. Ellis, Australia	White Leghorn.	36	48	48·0	
		37	36	36·0	
		38	67	67·0	Ditto.
		39	62	62·0	Ditto.
Messrs. Musson & Co., England.	Ex. Leghorn	40	53	52·4	Ditto.
Mr. A. Snowden, England	White Leghorn.	41	65	64·0	Ditto.
Mr. Welch, England	Buff Rocks	42	37	36·8	
		43	61	61·0	Ditto.
		44	50	49·8	
		45	52	51·6	Ditto.
Mr. F. Snowden, England	W. Wyandotte.	46	65	59·6	Ditto.
	W. Leghorn	47	31	31·0	
	Black Leghorn.	48	29	29·0	
Mr. A. Snowden, England	W. Wyandotte.	49	65	64·2	Ditto.

PERFORMANCES OF PULLETS ENTERED FOR THE TEST—*concld.*

Owner	Breed	Pen No.	Total of eggs	Total to score	Awards
Mr. W. Rogors, England .	White Leghorn.	50	61	60·2	All got 1st class certificates,
		51	55	51·8	
		52	55	[illegible]0·8	
		53	60	54·8	
Mr. Bradbury, England	White Leghorn.	54	40	39·2	
		55	60	59·8	1st class certificate.
	Light Sussox	33	72	71·6	Ditto. Also won special prize No. 3.
		34	60	58·2	1st class certificate.
U. P. P. A. . . .	Australorp	56	67	67·0	Ditto.
	W. Loghorn.	57	58	57·6	Ditto.

THE PREPARATION OF ORGANIC MATTER FOR THE COTTON CROP.

ONE of the directions in which the yield of cotton can be markedly increased is to supply the soil with fermented organic matter in a finely divid d condition. These matters have already been worked out empirically in China and Japan and are described in King's *Farmers of Forty Centuries*. All that is needed is to apply this work to Indian conditions and to make use of all existing raw materials. Almost any form of organic matter is suitable for the purpose. All that is needed is to mix the material with earth, wood-ashes (when available), a little cowdung or still better urine earth (to start fermentation in the right direction) and water. The final result is a finely divided manurial earth rich in nitrogen and organic matter. Fresh sann-hemp has yielded a very promising product containing 0·97 per cent. of nitrogen which is now being applied to cotton. Water weed from the local river gave similar results, the compost in this case containing about 0·5 per cent. of nitrogen. The experiments with cotton stalks are not yet complete. All the weeds and refuse organic matter produced on the Indore Experiment Station are now as a matter of routine converted into valuable manure and in due course find their way to the cotton fields. There is at present a serious waste of manure going on in India due to the fact that raw unfermented materials are applied to the soil. This practice is incorrect. The soil cannot prepare food materials and grow a crop at the same time. To attempt to make the soil do so is to overwork the land. The Chinese discovered the secret of avoiding this common mistake. They never overwork their fields and confine the activities of the soil to its proper function, namely, that of growing a crop. The preparation of food materials for the plant is always done outside the field. The successful introduction of this principle into Indian agriculture would lead to a great increase in the produc-

tion of cotton. As results accumulate on this subject at Indore, they will be published. [FROM *The Annual Report—for the year ended June 30th 1926—of the Institute of Plant Industry, Indore.*]

RAIN AS A CAUSE OF SPOTTING OF FOLIAGE.

FIELD observations having led to the conclusion that spotting of the foliage in apple trees in the wet season of 1924 was associated with the abnormal rainfall, Messrs. C. E. T. Mann and T. Wallace, of the Horticultural Research Station at Long Ashton, proceeded to examine the effect upon the foliage of these trees of temporary immersion in distilled water. As somewhat similar blotches appeared on these leaves, and as analysis showed that the distilled water was leaching considerable quantities of potash out of the leaves, the experiments were continued and showed that a variety susceptible to this spotting in the field, Cox's Orange, lost no less than 64 per cent. of the total potassium in the leaves after 24 hours' immersion in the water, whilst a variety resistant to spotting in the field in a similar experiment lost only 12 per cent. in 24 hours. In view of their experimental results with varieties of different susceptibility, as recorded in the *Journal of Pomology*, Vol. IV, pp. 146-161, there seems little doubt that the conclusion drawn from the field observations was justified, that rain was responsible for the spotting of the leaves noted in this particular season. It would also seem that the action of the rain water is associated with this little suspected capacity it has for leaching considerable quantities of soluble substances, including potassium compounds, out of the foliage of the plant. [*Nature*, No. 2918.]

THE ORIGIN OF CHROMOSOMAL MUTATIONS IN UVULARIA.

THE following is a summary of Mr. John Belling's paper on the subject in the *Journal of Genetics*, XV, No. 3 :—

(1) *Uvularia grandiflora* and *U. perfoliata* were forced in a greenhouse which was cooler at night. During the early months of two successive years no extensive aberrations were noticed. In the third year, apparently on account of excessive changes of temperature, abnormalities of chromosome distribution were marked.

(2) In one bud 70 per cent. of the pollen-mother-cells showed one or two (and sometimes more) detached chromosomes, or segments of chromosomes. The other buds examined had only a small percentage of such cases.

(3) In three other buds, ten cases of non-disjunction were observed. This non-disjunction was shown, in three cases, to occur at the first divi-

sion in the pollen mother-cell. It affected chromosome I, the largest chromosome, in half the cases. In one bud, non-disjunction was calculated to have occurred in 13 per cent. of the pollen-mother-cells from which those pollen-grains whose chromosomes were counted had arisen.

(4) Two undoubted cases of non-conjunction were seen. It is possible that some of the cases later than the first division, reckoned as non-disjunction, were due to non-conjunction.

(5) In one bud an extensive doubling of the chromosome number was observed. Of those pollen-grains whose chromosomes were counted, the giant pollen-grains formed nearly 12 per cent. This doubling is considered to have taken place by the omission of the second nuclear and cytoplasmic division.

(6) There were observed four cases of fracture of a chromosome at the constriction, in which the two segments had passed into different cells. In one such case the detached segment was attached to the end of the corresponding chromatid, homologous ends being apparently apposed.

(7) The phenomena of aberrant chromosome distribution observed in these *Uvularia* plants were of a nature to lead to the possible production of plants with chromosome groups of $2n+1$, $2n+2$, $3n$, $3n+1$, $3n-1$, $4n$, $4n+1$, $4n-1$, $4n+2$, $4n-2$, etc.; besides plants showing duplication of a segment of a chromosome.

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

BACTERIAL DETERIORATION OF SEED COTTON.

From an investigation of the bacterial deterioration of seed cotton and ginned cotton, stored in bags in the open and in closed cupboards in a closed laboratory, the author draws the following conclusions. Bacterial and fungoid infection, as a source of serious deterioration of cotton during damp storage, is to be sought for and controlled in the unginned rather than in the ginned cotton. Cotton which has been exposed to a very damp storage prior to ginning is much less resistant to bacterial or fungoid attack during subsequent normal storage than is cotton which has been stored under dry conditions prior to ginning and from the time of picking the crop. Ventilation of cotton during storage in seed represses possible bacterial and fungoid

deteriorative processes only in those cases where the damp material is able to "dry out" rapidly, otherwise such ventilation may lead to slightly increased deterioration of the cotton. Sun drying of the cotton is advocated in addition to ventilation, particularly prior to storage in seed and prior to baling after ginning. The process of damping cotton before or during baling is not recommended. [*Trans. Text. Inst.*, 1925, **16**, 185-196. A. C. BURNS.]

COTTON CULTIVATION IN S. AFRICA AND S. RHODESIA.

Owing to field crossing and seed mixing in the gins the South African crop is not uniform. Immediate improvement is sought from mass selection of Improved Bancroft and Zululand hybrid pending the results of single plant selection and the organization of the whole seed supply. The type required for the middle veld must mature early enough to avoid the frosts; and on the low veld a good medium staple jassid-resistant variety is required. Sufficient gins for the South Rhodesia crop are assured. For this colony as well as for North Rhodesia and Nyasaland the outlet problem for their produce is still unsolved. A bridge across the Zambesi to permit through railway traffic to Beira is required; and improved facilities in this port are also required. The Empire Cotton Growing Corporation has decided to take a financial interest in the Premier Cotton Estates Company of South Africa, which is developing 75,000 acres of land alongside the railway from Delagoa Bay to Johannesburg. Considerable developments are anticipated. [*Cotton News Weekly*, 1925, **2**, 367.]

MIXING OF RAW COTTON.

In a discussion on the mixing of cottons of different staple lengths, it is brought out that the greatest difficulty is not in the length of the staple so much as in mixing cottons grown in different parts of the country. Thus, a Strict Middling Oklahoma cotton, which is wiry and curly, will not mix with a Strict Middling cotton grown in any other State, which is silky and soft. Lumpy work and weak yarn will be produced. [*Cotton*, 1925, **89**, 807.]

FUNGUS MYCELIUM.

Further experiments on the analogy between plant tissue and an amphoteric colloid with a definite isoelectric point are described (Cf. A. 1924, 20, 49). The tissue to be examined was added to a small quantity of a dilute buffer mixture and the changes in reaction were measured at intervals until equilibrium was reached. Under the described conditions of experiment the tissues acted as amphoteric colloids with isoelectric points as follows: Potato-tuber tissue, pH 6·4; soy-bean root tips, Virginia variety, 6·2 to 6·44; *Gibberella saubinetii* mycelium, 6·2; *Fusarium lycopersici* mycelium, 5·5; and *Fusarium oxysporum* mycelium, 4·9. [*Jour. Agri. Res.*, 1925, **31**, 385-399. W. J. ROBBINS and T. T. SCOTT.]

Wax Content of Raw Cottons.

It is shown that wax content fails completely as a means of differentiating cottons of different origin but the properties of the wax from native Indian cottons are distinctive and enable these cottons to be distinguished from other varieties. The distinction is most marked in the saponification value, the values obtained being uniformly higher than any given by other varieties. In addition, the Indian waxes are characterized by low melting points, high acid and iodine values, and by a low percentage of unsaponifiable material. [*Jour. Text. Inst.*, 1925, **16**, T. 338-344. L. V. Lecomber and M. E. Probert.]

Cotton Production in Queensland.

Queensland cotton-growing history is briefly reviewed and some details of the course of the crop during the seasons since 1921 are given. The range of conditions in the cotton belt is extremely wide and the lack of homogeneity in the soils of the localities is particularly striking. Cotton growing instruction is difficult, for the exact cultural details have to be worked out in each separate area. Farmers are therefore encouraged to assist by conducting experiments themselves. The local soil and general environmental differences also result in distinct differences in the raw cotton produced, even when the same variety is planted. " Hill " cotton is thus of different character from that grown on adjacent alluvial flats.

Durango after three or four years is showing signs of new place effects. Slight variations are observable in the character of the staple, the habit of growth, earliness and other factors. Straight selections have been made and it is hoped to evolve from them even better types than the already successful general type. As no one variety is expected to meet the requirements of the whole of Queensland, other varieties such as Acala, Lone Star and Webber 49 are under trial.

The Government policy is to encourage the production of the highest quality cotton. A staple of at least full $1\frac{1}{8}$ in. to $1\frac{1}{4}$ in. and if possible averaging $1\frac{3}{16}$ is sought. In the times of low prices for this type of cotton it is hoped always to secure an average premium of 300 points. However, the maintenance of high quality cotton production is dependent on high quality cultivation, and an all round improvement in this respect is required if yield and quality are to be maintained.

There is little hope for cotton growing on the plantation scale in Queensland, on account of labour supply ; and the individual growers are urged to restrict their acreage to an area within their capacity to cultivate thoroughly. High yield of good quality cotton per acre should be the aim. [*Empire Cotton Growing Review*, 1925, **2**, 169-183. G. Evans.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. M. S. A. HYDARI, I.C.S., Under Secretary, has been appointed to officiate as Deputy Secretary to the Government of India, Department of Education, Health and Lands, *vice* Mr. G. S. Bajpai, C.I.E., O.B.E., I.C.S., placed on deputation out of India.

THE services of Mr. J. C. McDougall, M.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Central Provinces, have been placed at the disposal of the Government of India from 1st October, 1926, for employment as Assistant Secretary to the Royal Commission on Agriculture in India.

THE Government of Bombay has created a special post of Agricultural Chemist to Government outside the cadre of the Indian Agricultural service, and appointed Mr. D. L. Sahasrabuddhe, M.Sc., M.Ag., to hold it.

DR. G. S. CHEEMA, Horticulturist to Government, Bombay, has been granted leave on average pay for one month from 24th November, 1926, with permission to affix the Christmas holidays.

MR. R. W. LITTLEWOOD, N.D.A., Deputy Director of Agriculture, Live-Stock, Madras, has been granted leave on average pay for 8 months from 1st November, 1926, and study leave for 7 months in continuation thereof to study up-to-date improvements in dairying in England and on the Continent.

DURING the absence of Mr. C. Maya Das, on leave on medical certificate for six months from 26th April, 1926, the post of Principal, Agricultural College, Cawnpore, was held by Mr. P. K. Dey up to 27th September, 1926, and for the remaining period from that date by Mr. P. B. Richards.

Khan Sahib M. Abdul Qayum held charge of the current duties of Professor of Agriculture, Agricultural College, Cawnpore, *vice* Mr. C. P. Maya Das on leave.

Mr. G. C. Sherrard, B.A., Deputy Director of Agriculture, Patna Circle, Bihar and Orissa, was on leave for 17 days from 23rd September to 9th October, 1926.

Mr. S. Mubarik Ali Shah Gilani, B.Sc., M.R.C.V.S., and **Lala Pran Nath Nanda**, M.R.C.V.S., have been appointed to special temporary posts in the Civil Veterinary Department, Punjab, for a period of two years, and placed under training under the Chief Superintendent of the department.

International Society of Sugarcane Technologists.

The next Convention of the International Society of Sugarcane Technologists will be held in Havana. The meetings will open on 14th March, 1927, and continue for about a week, with side trips in and about Havana. Following this, an excursion will be made to other parts of Cuba either in small groups or by the convention in a body.

Among the subjects to be discussed are: Insect pests and diseases of sugarcane; sugarcane varieties and related problems of seed selection and seedling propagation; protective quarantine measures; field practices such as cultivation, fertilization, tillage, etc.; the operation and chemical control of the cane sugar factory.

REVIEWS

Root-development of Field Crops.—By J. E. Weaver. (London : McGraw-Hill Publishing Co., Ltd.) Price, 15*s*.

Notwithstanding the enormous number of field experiments and variety trials which have been carried out in the past in all parts of the world, comparatively little is known of the root-systems of agricultural crops. Investigators constantly lose sight of the fact that they see only half the plant under experiment and that the most important portion, the root-system, is below ground. Similar mistakes occur when the approach is made by way of studies of the soil. The greatest attention is paid to details relating to chemistry, physics and bacteriology but there is often no liaison with the mechanism which brings the plant and the soil into gear—the root-system of the plant. The result is a very partial presentation often of no great value from the point of view either of science or of practice. A change, however, is taking place and during the last few years more and more attention has been paid to root-development. In the United States, the University of Nebraska has taken a leading part in this new development and Weaver and his colleagues have issued a number of important papers which have recently appeared in the publications of the Carnegie Institution of Washington.

In the present book the results of twelve years' work have been brought together in a form particularly suitable for investigators and advanced students. The work opens with three introductory chapters on the environment of roots (the soil), their structure and the relation of root-habit to crop-production. The presentation of these preliminary matters is a model of its kind. All the essentials are rapidly and accurately reviewed and an admirable balance is maintained between the various factors involved. After dealing with the root habits of plants (indigenous to the United States) and how they indicate crop behaviour—a chapter in which a vast amount of recent work is summarized—the author deals in the following ten chapters with the roots of cultivated crops—wheat, rye, barley, maize, sorghum, various meadow and pasture grasses, sugar-beet, lucerne, clover, potato and sunflower. The book concludes with a section on the methods of studying root-development and an excellent bibliography.

While it is hardly possible to praise this work too highly, nevertheless two shortcomings must be mentioned. In the first place, the book deals only with the investigations in the United States and there is only incidental mention of work in other parts of the world. The author refers to this limitation in the preface in the following words : " No attempt has been made to include root studies other than those made in America, as this would have extended the work far beyond the scope of this

volume." Many investigators will share the reviewer's regret that this decision was made. At the moment, a critical review of all the investigations so far published on root-development and their relation to ecology and crop-production is urgently required and would do much to advance these subjects. No one is more fitted to undertake this task than the author of this volume. The second criticism to which this book is open concerns the general scope of the investigations. Too much stress has been laid on root distribution and insufficient attention has been paid to the progress of root activity during the life of the crop. The point of view is rather too static, and valuable as is a knowledge of root distribution throughout the life of the crop, it is equally necessary to know more about the actual zones where absorption is taking place and the extent of this activity. This information has then to be correlated with the above ground development of the plant. In spite of these shortcomings, which are inevitable in dealing with a new field of work, Professor Weaver is to be congratulated on having produced a book which is essential to the investigator of crop problems. It should also find a place in the libraries of the Agricultural Colleges and Agricultural Schools of India and its general findings should be incorporated in the curriculum. [A. H.]

Norwegian Agriculture.—BY O. T. BJANES, Director-General of Agriculture, Norway. (I. W. Cappelens, Forlag, Oslo.)

This publication, issued by the Department of Agriculture, Norway, gives a brief but interesting account of agriculture and rural economy in the western portion of the Scandinavian peninsula.

Norway is generally associated with the production of timber and forest products. Her agricultural resources, however, are being steadily fostered and developed. It is a land of small owner-occupied farms. Renting of agricultural land is very uncommon. The basis of the agricultural system is the production of live-stock—horses, cattle, sheep, pigs and goats—and the development of dairy produce. The compact intensively cultivated holdings, combined with large communal grazing grounds, are particularly suited for such a type of farming. Climatic conditions of the country necessitate all live-stock being housed and fed in-doors for nine months of the year. During the remaining three months, they maintain themselves on the mountain pastures with which the country abounds.

The chief cultivated crops are cereals—rye, barley, wheat and oats—and feeding crops—hay, green fodders and turnips. Potatoes are also being grown extensively. In the more southerly districts, fruit culture is becoming an important and valuable addition to farming operations. The sub-division of the land and the necessity of working at high pressure, during the short period when cultivation is possible, have created a surprisingly large demand for labour-saving implements and machinery.

The Norwegian State maintains a very complete organization—on the Danish model—to foster and develop the agriculture of the country. Two interesting sub-divisions of the State Agricultural Department are the "Cultivation Office," which has chiefly to do with the bringing of new land under cultivation and the colonization of waste lands, and the "Redistribution Office," which conducts the work of redistributing lands and forests where the situation of holdings is disadvantageous.

A chapter of special interest to all connected with the advancement of Indian agriculture, deals with the redistribution of mixed holdings. In Norway, much of the land has been held in common from ancient times and the dwellings of the cultivators are grouped together in small hamlets. The chief kind of tenure-in-common of cultivated land is that the various holders have separately marked off allotments. These, however, are now so mixed and interspersed with each other that a severe handicap is imposed on economic production and development. Several legal enactments to remedy this sytem of tenure have been passed and amended from time to time. Under the present law, a re-apportionment of rural properties with their appurtenances can be demanded when they are intermixed or in common ownership. Redistribution is carried out by special tribunals for each district. Each tribunal consists of a chairman, specially trained and appointed for this work by the State, and two nominated members. Applications for redistribution are sent to the chairman of the district tribunal who appoints a day for a meeting at the place in question. Notices are served on all occupiers of land interested in the area to be examined. If the demand for redistribution is approved by the tribunal, surveys and maps are prepared and a valuation of the area is made. On the basis of this valuation, the tribunal drafts a provisional scheme for redistribution. This scheme is submitted to the ground-owners and other interested parties for consideration. After such alterations as forthcoming objections necessitate, the redistribution is carried out. All disputes regarding occupancy of land are decided by the redistribution tribunal which has full powers even to the extent of being able to order the removal of houses, the closing of old roads, the construction of new roads, the diversion of water courses, etc., which the redistribution scheme may render necessary. The tribunal also allocates the cost of the work. If disputes arise, appeal can be made to a higher redistribution court. It is interesting to note that the redistribution laws give power, in certain cases, to buy out user's rights and to arrange for cases of joint ownership. At present, there are forty-eight chairmen of redistribution tribunals with eighty-nine assistants. The salaries of these officers are borne by the State which also supports the work of redistribution by means of grants, etc. The charge to the State amounts roughly to half the cost of the annual redistributions. The remaining half is borne by the parties concerned in the improvement.

The chapters on agricultural education in Norway are particularly interesting and complete. They indicate the very comprehensive facilities for practical training in all branches of agriculture and housewifery which have been provided by the State. The importance of subsidiary industries to agriculture, in a country where

work in the fields is limited to one quarter of the year, is fully realized. Special note may be made of the State Training School for teachers of small-holders in agriculture, dairying, and secondary rural industries. The interest of this publication is greatly enhanced by the large number of excellent photographs illustrating the text. [W. J. J.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Life of Plants, by Sir Frederick Keeble. (Clarendon Science Series.) Pp. xii + 256. (Oxford : Clarendon Press.) Price 5*s*. net.
2. Plant Products, by S. Hoare Collins and George Redington. Pp. xiii + 262. (London : Bailliare, Tindall and Cox.) Price 10*s*. 6*d*. net.
3. Manual of Dairy Science, by A. H. R. Amess and H. C. Johnson. Pp. 208. (Aukland, Melbourne and London : Whitcombe and Tombs.) Price 4*s*. 6*d*. net.
4. Plant Nutrition and Crop Production, by E. J. Russell. (Cambridge : At the University Press.) Price 12*s*. 6*d*.
5. Heredity, by A. F. Shull. Pp. 287. (New York and London : McGraw-Hill Publishing Co.) Price 15*s*.
6. Evolution, by J. Graham Kerr. Pp. xii+278 ; 2 plates. (London : Macmillan & Co.) Price 12*s*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs

1. Studies on Indian Thysanoptera, by Dr. H. H. Karny. (Entomological Series Vol. IX, No. 6.) Price, R. 1-8 or 2*s*. 6*d*.
2. New Species of Indian Gall Midges (Itonididæ), by E. P. Felt ; New Indian Geometridæ, by Lewis B. Prout, F.E.S. ; Description of *Laspeyresia stirpicola*, n. sp. (Lepidoptera), by E. Meyrick, F.R.S., with a short Note on the Life-history and Status, by C. S. Misra, B.A. (Entomological Series Vol. IX, Nos. 7-9.) Price, As. 5 or 6*d*.

List of Agricultural Publications in India from 1st February to 31st July 1926.

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	The Agricultural Journal of India, Vol. XXI, Parts II, III and IV. Price Re. 1-8 or 2*s.* per part. Annual subscription, Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	Review of Agricultural Operations in India, 1924-25. Price Rs. 2-2 or 4*s.*	Issued by the Agricultural Adviser to the Government of India.	Ditto.
3	Proceedings of the Board of Agriculture in India, held at Pusa on 7th December, 1925, and following days (with appendices). Price Re. 1-14 or 3*s.* 3*d.*	Ditto . . .	Ditto.
4	Agricultural Statistics of India, 1923-24. Vol. I, Price Re. 1; Vol. II, Price Re. 1.	Issued by the Department of Commercial Intelligence and Statistics, India.	Ditto.
5	Results of Spinning Tests on Standard Indian Cottons.	Issued by Indian Central Cotton Committee Technological Laboratory.	G. Claridge & Co., Ltd., Caxton Works, Bombay.
6	Comparative Spinning Tests on Machine-ginned and Saw-ginned Cotton—Punjab-American Type 289-F.	Ditto . . .	Ditto.
7	Some Modern Problems of Scientific Research for the improvement of Cotton Growing.	Issued by the Indian Central Cotton Committee.	The Times Press, Bombay.
8	A Note on the Growing of Green Manure Crops. Madras Department of Agriculture Leaflet 41. (Tamil only.)	N. S. Kulandaiswami Pillai, Assistant Director of Agriculture, Madras.	Government Press, Madras.
9	Note on Ensilage. Madras Department of Agriculture, Leaflet 43. (English, Tamil, Telugu, Malayalam and Kanarese.)	R. W. Littlewood, N.D.A., Deputy Director of Agriculture, Live Stock, Madras.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
10	Annual Report of the Department of Agriculture in the Bombay Presidency, 1924-25. Price Rs. 2-2.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
11	The Bhagnari Breed of Cattle in Sind and Baluchistan. Bombay Department of Agriculture Bulletin 126. Price As. 6.	H. G. Baluch, B.Ag., Officiating Live Stock Expert to Government, Bombay.	Yeravada Prison Press, Poona.
12	Elephant Grass. Bombay Department of Agriculture Bulletin 127 Price Anna 1.	Harold H. Mann, D.Sc., Director of Agriculture, Bombay.	Ditto.
13	Cotton Cultivation in Sind. Bombay Department of Agriture Bulletin 128. Price As. 3.	Khan Bahadur Gul Mohamed Abdur Rehman, Officiating Deputy Director of Agriculture, Sind.	Ditto.
14	Use of Wire for preventing lodging of Sugarcane in Konkan. Bombay Department of Agriculture Leafl t 1 of 1925.	Issued by the Department of Agriculture, Bombay.	Ditto.
15	Hints to Sann-hemp Growers in Panchmahals. Bombay Department of Agriculture Leaflet 2 of 1925.	Ditto . . .	Ditto.
16	New type of Tobacco Seed, No. 6. Bombay Department of Agriculture Leaflet 5 of 1926.	Ditto . . .	Ditto.
17	List of Implements recommended by the Agricultural Department for the Deccan and Karnatak Districts. Bombay Department of Agriculture Leaflet 6 of 1926.	Ditto . . .	Ditto.
18	Annual Report of the Department of Agriculture, Bengal, 1924-25. Price Rs. 5.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depot, Calcutta.
19	Activities of the Department of Agriculture. Bengal. (English and Bengali).	Rai Sahib D. N. Mitra, L.Ag., District Agricultural Officer, Faridpur, Bengal.	Ditto.
20	Season and Crop Report of Bengal, 1925-26. Price Re. 1-8.	Issued by the Department of Agriculture, Bengal.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
21	Season and Crop Report, Bihar and Orissa, 1925-26.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Bihar and Orissa, Gulzarbagh.
22	Present Position of Cotton in the unirrigated tracts of United Provinces.	B. Ram Prasad, Assistant Economic Botanist to Government, United Provinces.	Government Press, United Provinces, Allahabad.
23	Note on Barley in United Provinces.	Ditto . . .	Ditto.
24	Report on the Operations of the Department of Agriculture, Punjab, 1924-25. Part I: Price Rs. 3-8.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
25	Prospectus of the Punjab Agricultural College, Lyallpur, 1926.	Ditto . . .	Ditto.
26	Seasonal Notes, April 1926. Price As. 3.	Ditto . . .	Ditto.
27	Rates of Food Consumption by Zemindars in the Tallaganj Tahsil of the Attock District. Punjab Board of Economic Enquiry, Rural Section Publication 6. Price As. 6.	C. B. Barry, M.A., I.C.S., Settlement Officer, Attock.	Civil and Military Gazette Press, Lahore.
28	Sixty years of Punjab Food Prices, 1861-1920. Punjab Board of Economic Enquiry, Rural Section Publication 7. Price As. 10.	W. H. Myles, M.A., Professor of Economics, Punjab University.	Ditto.
29	Report on the Agricultural Stations in the Southern Circle, Central Provinces, 1924-25. Price Re. 1-4.	G. K. Kelkar, B.A., Deputy Director of Agriculture in charge, Southern Circle, Central Provinces.	Government Press, Central Provinces, Nagpur.
30	Report on the Demonstration Work carried out in the Southern Circle, Central Provinces, 1924-25. Price As. 8.	G. K. Kelkar, B.A., Deputy Director of Agriculture in charge, Southern Circle; and T. K. Ghatpande, Extra Assistant Director of Agriculture, Central Provinces.	Ditto.
31	Report on the Agricultural Stations in the Eastern Circle, Central Provinces, 1924-25. Price Rs. 2.	Rao Bahadur T. L. Powar, B.A., Officiating Deputy Director of Agriculture, Eastern Circle, Central Provinces.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
32	Report on the Demonstration Work carried out in the Eastern Circle, Central Provinces, 1924-25. Price As. 5.	Nand Kishore, L.Ag., Extra Assistant Director; and Rao Bahadur T. L. Powar, B.A., Officiating Deputy Director of Agriculture, Eastern Circle, Central Provinces.	Government Press, Central Provinces, Nagpur.
33	Report on the Agricultural Stations in the Western Circle, Central Provinces, 1924-25. Price Re. 1-8.	S. G. Mutkekar, B.Ag., M.Sc., Deputy Director of Agriculture, Western Circle; and W. Youngman, B.Sc., Economic Botanist for Cotton, Central Provinces.	Ditto.
34	Report on the Demonstration Work carried out in the Western Circle, Central Provinces, 1924-25. Price Re. 1-13.	S. G. Mutkekar, B.Ag., M.Sc., Deputy Director of Agriculture, Western Circle, Central Provinces.	Ditto.
35	Report on the Agricultural Stations in the Northern Circle, Central Provinces, 1924-25. Price Rs. 4-8.	J. H. Ritchie, M.A., B.Sc., Deputy Director of Agriculture; and E. A. H. Churchill, B.Sc., Assistant Director of Agriculture, Northern Circle, Central Provinces.	Ditto.
36	Report on the Demonstration Work carried out in the Northern Circle, Central Provinces, 1924-25. Price Re. 1.	Rao Sahib B. L. Dubey and Govind Prasad, Extra Assistant Directors of Agriculture, Central Provinces.	Ditto.
37	Report on the Agricultural College, Nagpur, Chemical, Botanical, Mycological, Entomological Research, Agricultural Engineer's Section and Maharajbagh Menagerie, 1924-25. Price Re. 1-2.	R. G. Allan, M.A., Principal, Agricultural College; H.E. Annett, D.Sc., Agricultural Chemist; W. Youngman, B.Sc., Economic Botanist for Cotton; J. F. Dastur, M.Sc., Mycologist; J. L. Khare, L.Ag., Entomological Assistant; H. Copley, Agricultural Engineer, Nagpur.	Ditto.
38	Report on the Experimental Farm attached to the Agricultural College, Nagpur, 1924-25. Price Re. 1-12.	R. G. Allan, M.A., Principal, Agricultural College, Nagpur.	Ditto.

List of Agricultural Publications—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
39	Report on the Cattle-breeding Operations in the Central Provinces and Berar, 1924-25. Price As. 9.	S. T. D. Wallace, B.Sc., Deputy Director of Animal Husbandry, Central Provinces.	Government Press, Central Provinces, Nagpur.
40	Agricultural Calendar, Burma, 1926-27. (Burmese.)	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
41	Report of the Principal, Agricultural College and Research Institute, Mandalay, 1924-25.	Ditto . . .	Ditto.
42	Economic Survey of the Sugarcane Industry in the East Central, Tenasserim and Northern Agricultural Circles, Burma. Burma Department of Agriculture Bulletin 23.	Ditto . . .	Ditto.
43	Practical Suggestions to Orange Growers.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
44	Report of the Agricultural Stations at Tarnab and Haripur in the North-West Frontier Province, 1924-25. Price As. 7.	W. Robertson Brown, Agricultural Officer, North-West Frontier Province.	North West Frontier Province Government Printing and Stationery Office, Peshawar.
45	Summary of Remarks on the Kharif Crop of the North-West Frontier Province for 1925-26. Price As. 6.	Issued by the Revenue Commissioner, North-West Frontier Province.	Ditto.
46	A Note on the Consolidation of Holdings in Mysore.	A. K. Yegna Narayan Iyer, M.A., Dip.Agri., N.D.D., F.C.S., Deputy Director of Agriculture, Mysore State.	Government Press, Bangalore.
47	Report on the working of the Amrit Mahal Department, Mysore, 1924-25.	Issued by the Department of Agriculture, Mysore State.	Ditto.
48	Annual Report of the Department of Agriculture, Baroda State, 1923-24. Price Re. 1-7.	Issued by the Department of Agriculture, Baroda State.	Baroda State Press, Baroda.
49	Annual Report of the Departments of Agriculture and Agricultural Engineering, Gwalior Government, 1924-25.	Issued by the Department of Agriculture, Gwalior.	A. D. Press, Gwalior.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		***General Agriculture*—contd.**	
50	Report on the Administration of the Department of Agriculture and Village Panchayets in the Cochin State, 1925-26.	Issued by the Superintendent of Agriculture and Panchayets, Cochin State.	Cochin Government Press, Ernakulam.
51	*Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual subscription, Rs. 3.	Mysore Agricultural and Experimental Union.	Bangalore Press, Bangalore.
52	*Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription, Rs. 4; single copy, As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
53	*The Planters' Chronicle* (Weekly)	United Planters' Association of South India, Madras.	Ditto
54	*Rural India* (Monthly). Annual subscription, Rs. 3.	A. Swaminatha Aiyar, Editor.	Forest Panchayet Banking Union, Madras.
55	*Poona Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 2; single copy, As. 10.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
56	*The Old Boys' Magazine, Agricultural College, Cawnpore* (Quarterly). Price As. 8 per copy; annual subscription, Rs. 2.	M. L. Saksena, L.Ag., Editor.	Cawnpore Printing Press.
57	*The Allahabad Farmer* (Quarterly). Single copy, As. 8; annual subscription, Rs. 2.	W. B. Hayes, A. Sinha and N. R. Joshi, Editors.	The Mission Press, Allahabad.
58	*Nagpur Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 3.	R. A. Ramayya and R. B. Ekbote, Editors.	Udyama Desh Sevak Press, Nagpur.
59	*The Bengal Agricultural Journal* (Quarterly). (In English and Bengali.) Annual subscription, Re. 1-4; single copy, As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
60	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
61	*Indian Scientific Agriculturist* (Monthly). Annual subscription, Rs. 4.	H. C. Sturgess, Editor; J. W. McKay, A.R.C.Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Co., 52-53, Bowbazar St., Calcutta.
62	*Rural Bengal*	N. N. Gupta, B.A., Ph.D., B.Sc., Editor.	Sreemat Bhagabat Press, Bhowanipore, Calcutta.
	AGRICULTURAL CHEMISTRY		
63	Determination of available Phosphoric Acid of Calcareous Soils. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 6. Price As. 12 or 1*s.* 3*d.*	Surendralal Das, M.Sc., Assistant to the Imperial Agricultural Chemist.	Government of India Central Publication Branch, Calcutta.
64	Drainage Waters at Cawnpore. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 8. Price As. 10 or 1*s.*	H. N. Batham, M.A., F.I.C.S., Agricultural Chemist to the Government of United Provinces.	Ditto.
65	Nutrients required for Milk Production with Indian Foodstuffs. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 9. Price As. 14 or 1*s.* 6*d.*	F. J. Warth, M.Sc., Physiological Chemist, Bangalore; Labh Singh, L.Ag., B.Sc. (Agri.); and S. M. Hussain, B.Sc.	Ditto.
66	Silage Experiments at Nagpur. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 10. Price As. 10 or 1*s.*	Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., Agricultural Chemist to the Government of Central Provinces; and A. R. Padmanabha Aiyer, B.A.	Ditto.
67	Nutrients required for Growth Production with Indian Foodstuffs. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 11. Price As. 3 or 4*d.*	F. J. Warth, M.Sc., Physiological Chemist, Bangalore; and Izaz Ahmad, B.Sc. (Agr.).	Ditto.
68	Standard Methods of Analysis of Fertilizers. Pusa Agricultural Research Institute Bulletin 164. Price As. 4 or 6*d.*	J. Sen, M.A., Ph.D., Officiating Imperial Agricultural Chemist.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	***Agricultural Chemistry*—concld.**		
69	The Chemical Composition of the Food Grains, Vegetables and Fruits of Western India. Bombay Department of Agriculture Bulletin 124. Price As. 3-6.	D. L. Sahasrabuddhe, M.Sc., M.Ag., Agricultural Chemist to Government, Poona.	Yeravada Printing Press, Poona.
	BOTANY		
70	Studies in Gujarat Cottons, Part III. The Wagad Cotton of Upper Gujarat, Kathiawad and Kutch. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIV, No. 2. Price Re. 1-4 or 2*s*. 3*d*.	Maganlal L. Patel, M.Ag., and D. P. Mankad, Cotton Breeders, Gujarat.	Government of India Central Publication Branch, Calcutta.
	MYCOLOGY		
71	The Diseases of Para Rubber in Burma. Burma Department of Agriculture Bulletin 14.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
72	The Diseases of Rubber in Burma (Burmese). Burma Department of Agriculture Cultivators' Leaflet 54.	Ditto . . .	Ditto.
	ENTOMOLOGY		
73	The Red Pumpkin Beetle (*Aulacophora abdominalis*, Fb.) and its Control; with a short Note on *A. atripennis*, Fb. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. IX, No. 4. Price Re. 1 or 1*s*. 9*d*.	M. Afzal Husain, M.Sc., M.A., Entomologist to the Government of Punjab; and S. Abdullah Shah, L.Ag.	Government of India Central Publication Branch, Calcutta.
74	Experiments on the Transmission of Rinderpest by means of Insects. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. IX, No. 5. Price Rs. 2-4 or 4*s*. 2*d*.	S. K. Sen, B.Sc., F.E.S., Assistant to the Imperial Entomologist.	Ditto.
75	Bot Flies of the Punjab. Pusa Agricultural Research Institute Bulletin 160. Price As. 14 or 1*s*. 6*d*.	H. E. Cross, M.R.C.V.S., D.V.H., A.Sc., Camel Specialist, Punjab.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Entomology—concld.		
76	Tentative Keys to the Orders and Families of Indian Insects. Pusa Agricultural Research Institute Bulletin 162. Price Re. 1-4 or 2*s.* 3*d.*	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist.	Government of India Central Publication Branch, Calcutta.
77	Catalogue of Indian Insects. Part 10—Stephanidæ. Price As. 5 or 6*d.*	G. R. Dutt, B.A., Personal Assistant to the Imperial Entomologist.	Ditto.
78	*Tela* (Aphis) on Orange. Punjab Department of Agriculture Leaflet 9.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
79	The *Katra* or Hairy Caterpillar of Gujarat. Bombay Department of Agriculture Leaflet 4 of 1926.	Issued by the Department of Agriculture, Bombay.	Yeravada Prison Press, Poona.
	VETERINARY		
80	Annual Report of the Imperial Institute of Veterinary Research, Muktesar, 1924-25. Price Re. 1-14 or 3*s.* 3*d.*	J. T. Edwards, B.Sc., M.R.C.V.S., Director.	Government of India Central Publication Branch, Calcutta.
81	Foot and Mouth Disease. Madras Veterinary Department Leaflet VIII (English, Tamil, Telugu, Malayalam, Kanarese and Oriya).	D. A. D. Aitchison, M.R.C.V.S., Veterinary Advisor to the Government of Madras.	Government Press, Madras.
82	Annual Report on the Punjab Veterinary College, Civil Veterinary Department, Punjab, and the Government Cattle Farm, Hissar, 1924-25. Price Rs. 2-12.	Issued by the Agricultural Department, Punjab.	Government Printing, Punjab, Lahore.
83	Annual Report of the Camel Specialist, Sohawa, for the year 1924-25. Price As. 8.	Ditto . . .	Ditto.
84	Prospectus of the Punjab Veterinary College, Lahore, 1926.	Ditto . . .	Ditto.
85	Foot and Mouth Disease, Control by Chemotherapy. Punjab Veterinary Bulletin 17.	Col. G. K. Walker, C.B.E., C.I.E., F.R.C.V.S., and W. Taylor, M.R.C.V.S., Punjab Veterinary College.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

No.	Title	Author	Where published
	Veterinary—concld.		
86	Annual Report of the Civil Veterinary Department in Mysore, 1924-25.	Issued by the Department of Agriculture, Mysore State.	Government Press, Bangalore.
87	*The Indian Veterinary Journal* (Quarterly). Annual subscription, Rs. 4 for members of All-India Veterinary Association and students; Rs. 8 for others.	P. Srinivasa Rao, G.M.V.C., Editor.	Methodist Publishing House, Madras.

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